THE

KANSAS UNIVERSITY SCIENCE BULLETIN.

Vol. VIII, No. 1—July, 1913.

(Whole Series, Vol. XVIII, No. 1.)

CONTENTS:

PUBLISHED BY THE UNIVERSITY,

LAWRENCE, KAN.

Entered at the post-office in Lawrence as second-class matter.

5-888

To Mrs. F. H. Snow.
With Kind Regards
S. J. Hunter.

13.

THE

KANSAS UNIVERSITY SCIENCE BULLETIN.

DEVOTED TO THE PUBLICATION OF THE RESULTS OF RESEARCH
BY MEMBERS OF THE UNIVERSITY OF KANSAS.

VOL. VIII.

ENTOMOLOGY NUMBER.

PUBLISHED BY THE UNIVERSITY,
LAWRENCE, KANSAS.
1914.

Yours sincerely
F. H. Snow

DEDICATED

TO THE MEMORY

OF

FRANCIS HUNTINGTON SNOW,

BY

THE GRADUATE STUDENTS OF THE DEPARTMENT OF ENTOMOLOGY OF THE UNIVERSITY OF KANSAS, IN APPRECIATION OF THE OPPORTUNITIES FOR RESEARCH MADE POSSIBLE BY HIM.

CONTENTS OF VOLUME VIII.

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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

VOL. VIII, No. 1] JULY, 1913. [WHOLE SERIES VOL. XVIII, NO 1

Department of Entomology of the University of Kansas.

HISTORICAL ACCOUNT.

BY S. J. HUNTER.

THIS, the second entomology number of this Journal, is introduced by an account and bibliography of the work of the department of entomology of the University of Kansas. The volume itself is intended as a tribute, in a small measure, to the work of the founder of the department.* Doctor Snow, a member of the faculty of the University of Kansas from the foundation of the University, was for many years professor of natural history, and his impress, especially on the museum side, on so many branches of this subject, is such that those who are now going over his work marvel at the wonderful capacity of the man. He was, as well, a great, desirable teacher. Entomology is very early shown to have been his favorite branch. It is especially fitting that the accomplishments in his favorite work should be recorded, and it seems best to present these chronologically.

The scope and activity of the department of entomology of the University of Kansas is therefore probably best shown by a transcript from the records of the department giving the work accomplished and official publications issued.

* It is regretted by the author that the arrangement under which this Journal is now published is such that prolonged delays sometimes prevent its regular appearance. But for this reason this issue would have appeared at a much earlier date.

1866.—FRANK H. SNOW, Professor of Mathematics and Natural Sciences.

In the senior year of the college instruction was given in zoölogy, and the principal branch of the subject treated was the insect fauna of the state.

This course was continued until 1886, when there began to be given special courses devoted exclusively to the subject of entomology.

1867.—Doctor Snow relinquishes mathematics and becomes professor of natural history.

1872.—Dr. F. H. Snow, of the University, was appointed chairman of the entomological commission of the Kansas Academy of Science, and was continued in this position for many years.

1874.—Doctor Snow begins publication of entomological papers in Transactions of Kansas Academy of Science.

1875.—An account of the Rocky Mountain locust, published in the Transactions of the Kansas Academy of Science. The same year Doctor Snow published a paper on a moth of economic importance, in the same Transactions. Another paper of this same year, which clearly shows the scope of the departmental work, is "The best means of defense against the insect enemies of the horticulturist," also published in the Transactions of the Kansas Academy of Science.

Mr. George F. Gaumer, an assistant, issued a publication on the larvæ of certain insects.

1876.—A publication by Doctor Snow from the University, entitled "List of Coleoptera collected in Colorado."—Trans. Kan. Acad. Sci.

Another paper, which dealt largely with the relation of birds and insects to agriculture, was issued this same year.

1877.—A publication appeared in the Transactions of Kansas Academy of Science, giving a list of the insects of Wallace county, Kansas. Two other papers the same year in the Transactions of the Kansas Academy of Science gave an account of a large tiger beetle of unusual scientific importance.

1880.—Appears a discussion by Doctor Snow on the webworm.

1882.—An account of the house fly is published in *Psyche*, III.

1883.—Was a year of unusual activity among injurious insects, and we find four papers of rather wide scope, on three noxious insects; on three injurious insects; on the habits of the screw worm; and on how to destroy these injurious insects. These were published in the first and second reports of the Kansas State Board of Agriculture and in *Psyche*.

1884.—We find another year of activity, as is shown by the publications in the reports of the Kansas State Board of Agriculture, on insects injurious to wheat and on the value of several insecticides.

1885.—This was an even more active year among insects injurious to crops. At this time there appeared in the Kansas State Board of

Agriculture reports a paper on injurious insects from July to September; on the chinch bug; on pear blight; and on further injurious insects—the Hessian fly, the wheat-straw worm, and the webworm.

1886.—This year the department begins to offer specially advanced courses in entomology.

1887.—There appeared in *Science* an article on the purslane worm.

1888.—This year began extended work of investigation with the chinch bug; an account of it is given in the report of the Kansas State Board of Agriculture. Another paper on insects injurious to wheat appeared in this same report.

1889.—Work had developed so that a number of departments were established. Doctor Snow now professor of botany, entomology and meteorology.

Further reports on the chinch bug were issued in the Board of Agricultural reports; and one on the experiments for the artificial dissemination of a contagious disease among chinch bugs was published in the Transactions of the Kansas Academy of Science.

V. L. Kellogg, assistant professor in the department of entomology, published some notes on bird lice, in the Transactions of the Kansas Academy of Science.

1890.—Doctor Snow becomes chancellor of the University.

Two reports on the experiments for the artificial destruction of the chinch bug were published in the reports, and one on the general question of the chinch bug.

1891.—This year House bill No. 639 was passed, "An act to establish an Experimental Station at the State University of Kansas, to promote and conduct experiments for the destruction of chinch bugs by contagion or infection, and making appropriation therefor."

Director of the Experiment Station of the University of Kansas was created, and Doctor Snow was elected to this position.

Papers on insects injuring Kansas wheat, on the results of the experiments carried on, and on the contagious diseases of the chinch bug were published in the State Board report, in *Insect Life*, and in the first annual report of the Experiment Station of the University of Kansas.

1892.—J. M. Aldrich, a graduate student in the department, published six papers on Diptera.

Three more papers on the chinch bug and its contagious diseases appeared, one in the second annual report of the Experiment Station, another in *Insect Life*, and the third in the report of the Kansas State Board of Agriculture.

With the assistance of V. L. Kellogg, Doctor Snow published a paper on two grain insects, in the bulletin of the department of entomology of the University of Kansas. Later the same year Doctor Snow published another article on the chinch bug in *Psyche.*

Assistant Professor V. L. Kellogg published two articles—notes on the comparative anatomy of insects; two on insects injurious to drugs;

insect notes, in Transactions of the Kansas Academy of Science; a 117-page bulletin—an account of common injurious insects of Kansas; and assisted Doctor Snow with his bulletin on two grain insects.

1893.—Doctor Snow published another report of the diseases of the chinch bug, in the third annual report of the Experiment Station of the University of Kansas.

Mr. Kellogg published a paper on the horn fly of cattle, with Doctor Snow, in the bulletin of the department of entomology. He also published a paper on the destruction of insects by fungi.

In this year W. A. Snow succeeded to the position of assistant professor, and Mr. Kellogg became head of the department of entomology at Leland Stanford University.

1894.—Doctor Snow published his fourth annual report of the Experiment Station, giving an account of his work with the chinch bug for that year. He also gave, in *Insect Life*, an account of the work in economic entomology at Kansas University for the season of 1894.

Some further papers of Kellogg's were published two more articles on insects injuring drugs, one on the anatomy of insects, and one on European experiments with insect diseases.

Mr. Hugo Kahl was appointed systematic entomologist, assistant in Entomological Museum.

1896.—A further report by Doctor Snow on the contagious diseases of the chinch bug, in the sixth annual report of the University Experiment Station.

S. J. Hunter published some notes on injurious insects, in Transactions of Kansas Academy of Science.

Mr. Hunter, who became assistant professor at this time, went to the western part of the state, where he began a special study of the grasshopper problem.

At request of Kansas nurserymen, S. J. Hunter began the annual inspection of Kansas nurseries.

Mr. Kahl, systematic entomologist, and curator of entomological collections.

1897.—Doctor Snow, together with S. J. Hunter, published a bulletin on the more destructive grasshoppers of Kansas. Disking of alfalfa first advocated, now a valuable practice.

1898.—Doctor Snow's title now becomes professor of organic evolution and entomology.

Mr. Hunter published a bulletin on scale insects injurious to orchards. Two papers by Hunter appeared in *Psyche;* they treated of the grasshoppers in Kansas and Colorado. Another paper on the influence of the parasites on grasshoppers appeared in the *Kansas University Quarterly*, and the same, with additions, as a bulletin of the department of entomology. Hunter also began his book on the Coccidæ of Kansas, publishing part I in the *Kansas University Quarterly*.

1899.—Assistant Professor Hunter published an account of his work in western Kansas in the bulletin entitled "Alfalfa, grasshoppers, bees; their relationships." Part II of the Coccidæ of Kansas appeared this year. In the report of the Kansas State Board of Agriculture was published an article on the fertilization of the alfalfa blossom by bees, an important note for growers of alfalfa. "The nurseryman and the entomologist" was given before the American Asociation of Nurserymen. "Entomological legislation in the interests of horticulture"—Transactions Kansas State Horticultural Society.

This year shows the broadening of the field of the work of the department among the nurserymen of the state. The governor, at request of Kansas nurserymen, appointed S. J. Hunter state inspector of nurseries. This appointment was continued until 1907.

1900.—The third part of Coccidæ of Kansas, by S. J. Hunter, was published in *Kansas University Quarterly*, vol. IX, No. 2.

"Alfalfa culture and insect life" appeared in the Kansas State Board of Agriculture report.

"Some entomological problems in horticulture," by S. J. Hunter, was published in the report of the Colorado State Board of Horticulture, vol. XI.

An article on spraying was given in the report of the Kansas State Board of Horticulture.

1901.—Doctor Snow returns to his old title, professor of natural history and director of the museum.

The fourth part of the Coccidæ of Kansas appeared in the *Kansas University Quarterly*, vol. X.

An article on selection, natural and artificial, was published in the *Western Fruit Grower* for October of this year.

The *American Journal of Physiology* published the results of Professor Hunter's summer study of sea urchin eggs, at Woods Hole, Mass.

Marguerite E. Wise instructor in botany and entomology.

Prof. S. J. Hunter becomes head of the department of entomology at the University.

1902.—Doctor Snow's title becomes professor of organic evolution, systematic entomology and meteorology.

Professor Hunter published a textbook dealing with the insect fauna of Kansas.

Mr. E. S. Tucker was appointed museum assistant in systematic entomology.

1903.—The various papers on the Coccidæ of Kansas were brought together as a textbook for use in identification of the scale insects.

Results of further biological investigations of Professor Hunter were published in the *Biological Bulletin*, vol. V, No. 3.

1904.—C. E. Sanborn, an advanced student in the department, published a paper on Kansas plant lice.

Another student at this time, Mr. W. J. Meek, published a paper on the structure of some insects, in the *Kansas University Science Bulletin*, vol. II.

1906.—C. E. Sanborn published a further account of plant lice of Kansas, giving a list of them and of their host plants. This paper is of great use in distinguishing the beneficial and injurious forms.

1907.—Report of the entomologist of the Kansas State Horticultural Society.—Trans. Kan. Acad. Sci., vol. XXIX.

The legislature designated the professor of entomology at the University as state entomologist.

The Kansas millers, grain men, and wheat growers raised a fund of about $2500 and asked this department to cope with the green-bug invasion.

P. A. Glenn was made assistant professor of entomology.

CHAPTER 386, LAWS OF 1907.

Creating a State Entomological Commission and Making an Appropriation Therefor.

AN ACT for the protection of the horticultural and agricultural interests of the state of Kansas by the suppression and extermination of San José scale and other injurious insect pests and plant diseases; to create the Kansas Entomological Commission, two state entomologists; and to provide for the punishment for violations thereof, and making appropriations therefor.

SEC. 4. That it shall be the duty of said state entomologists, under the control of the State Entomological Commission, to seek out and suppress pernicious insect pests and injurious and contagious plant diseases hereinbefore mentioned as destructive to the horticultural and agricultural interests of this state, and conduct experiments when necessary to accomplish that end.

1908.—September 20, Doctor Snow's death must here be recorded.

"Experiments with and knowledge of the green bug to date" is found in the report of the Kansas State Board of Agriculture, vol. XXVII, No. 105, by S. J. Hunter.

Report of the state entomologist of Entomological Commission of Kansas.—State report.

1909.—There was published a complete report of the green bug and its natural enemies and telling how to combat it. By S. J. Hunter and P. A. Glenn.

Professor Hunter, jointly with Prof. T. J. Headlee, sent out a circular of information regarding the San José scale, enemy of the fruit grower.

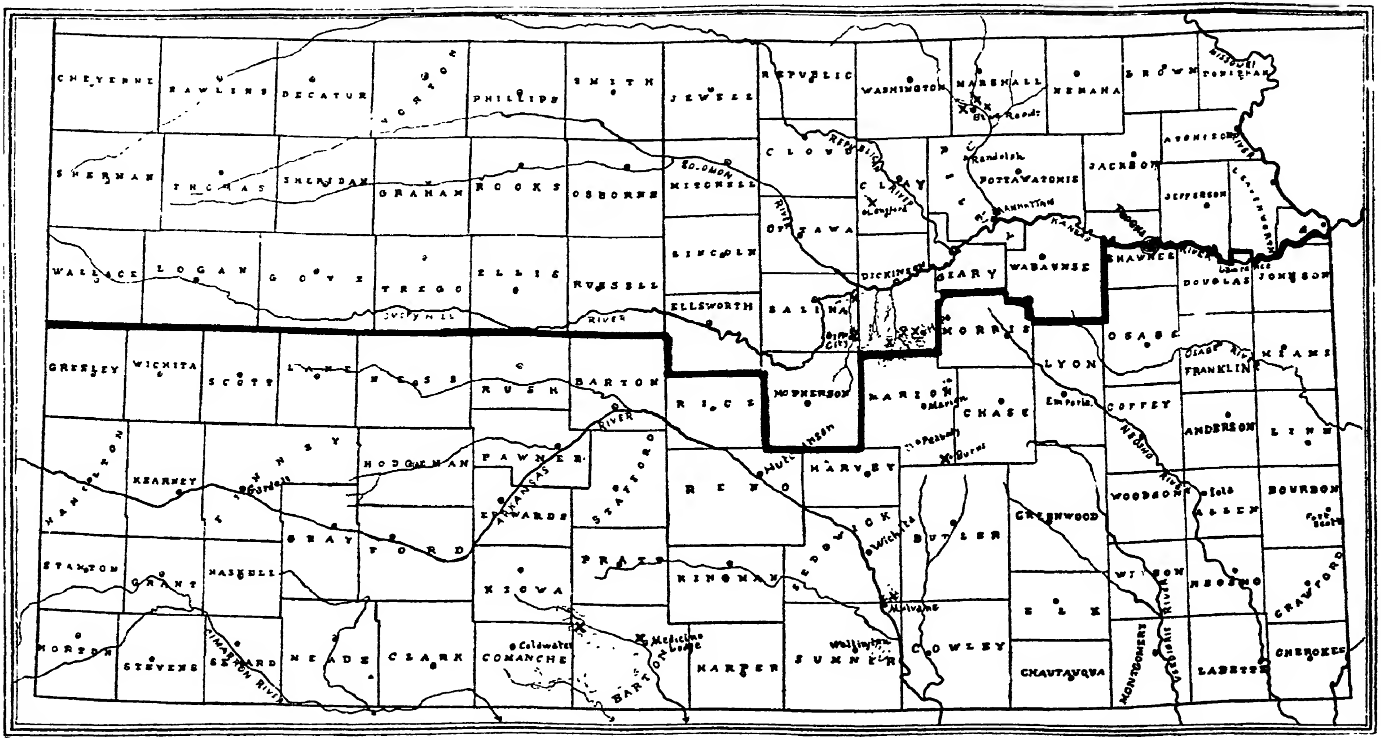
Began a systematic survey of orchard culture and management in Kansas.

1910.—The department of entomology and the department of botany work upon a fundamental investigation of the efficiency of the artificial distribution of the chinch-bug fungus. Professor Billings for botany, Professor Glenn for entomology, working jointly.

Orchard survey continued.

1911.—At request of Kansas millers, conducted special investigation on green bug on southern tier of counties.

Extended orchard survey to practically all of the apple-growing districts of the southern half of the state.



NOTE.—For expediency in the conduct of its field-work the Entomological Commission has assigned the southern half of the state to the State Entomologist at Kansas University, Lawrence, and the northern half to the State Entomologist at the Agricultural College, Manhattan. Therefore, inquiries from the two section hown on map by the heavy east-and-west line should be directed as above.

Professor Glenn called upon by the state entomologist of Minnesota to conduct entended investigations on the grasshopper in Minnesota.

H. B. Hungerford appointed instructor in entomology.

Departments of entomology and botany published for the United States Department of Agriculture a comprehensive bulletin dealing with the diseases of the chinch bug, Professors Billings and Glenn authors.

At the request of the State Board of Health, the department undertook a serious investigation of the relations existing between the newly introduced disease of pellagra and the sand fly.

H. W. Lohrenz appointed Griesa research fellow in entomology.

1912.—Head of department gives an address before the annual meeting of the American Association of Nurserymen at St. Louis.

Results thus far of work of sand fly and pellagra published in the *Journal of the American Association Medicine*, Chicago.

R. Fraser, Toronto, Canada, appointed to research fellowship in entomology.

Head of department appointed one of a committee of five, representing all parts of the United States, to coöperate in drafting and aiding the passage of a federal law protecting this country against further introduction of injurious insects and plant diseases from foreign countries. The plans formulated by all interests concerned were accepted, and incorporated in the law, which became effective August 20 of this year.

Head of department represented Kansas at the third triennial conference of the National Association for the Study of Pellagra.

Supreme court handed down a decision, all judges concurring, establishing the constitutionality of the law under which the economic work of this department is carried on.

Hungerford and Williams published a paper on "Some Kansas parasitic bees."

In response to a request from the governor of the state, the chancellor appointed the head of the department as chairman of a committee to investigate the horse plague then present in western Kansas.

1913.—Orrel M. Andrews, of Fairmount College, appointed research fellow in entomology.

Dwight Isely, who has just received his master's degree in this department, appointed to Schuyler fellowship in entomology, Cornell University, Ithaca, New York.

Mr. H. B. Hungerford made assistant professor of entomology.

THE ENTOMOLOGICAL MUSEUM, ESTABLISHED IN 1870.

HISTORICAL SUMMARY OF ITS DEVELOPMENT.

1870.—Collected by Doctor Snow: 500 specimens (250 species) of insects.

1872.—Donated by students of the University of Kansas, under direction of Professor Snow: 800 specimens of Kansas insects, of which 600 were contributed by Geo. F. Gaumer, and 150 by Samuel Carson.

1873.—Donations:

By students of the University: 300 specimens Kansas insects.
By Professor F. H. Snow: 400 specimens Kansas insects.

1874.— Important aid in the study of natural history is afforded by the cabinet collections, which contain upwards of 12,000 specimens, illustrating chiefly the departments of botany, entomology, and geology.

Donations:

By Geo. F. Gaumer: 300 specimens of Kansas insects.
By E. B. Noyes: 200 specimens of Kansas insects.

1876.—"The collections in entomology have been greatly increased during the past year, chiefly through the voluntary contributions of University students, and now include upwards of 2000 species of Kansas insects.

Donations:

By Prof. F. H. Snow: 4000 Kansas insects; 200 foreign insects.
By Geo. F. Gaumer: 3000 Kansas insects.
By Collin Timmons: 800 Kansas insects.
By Andrew Atchison: 500 Kansas insects.

"The first collecting trip that Doctor Snow made, outside of the vicinity of Lawrence and Douglas county, was in 1876, to Colorado Springs and Pike's Peak. Five members of the graduating class of that year organized a scientific expedition for 'exploration in Colorado.' Professor Snow was invited to accompany the expedition. During the first week of August the student members of the party returned home. Professor Snow and his wife and son Willie remained until September 1."

1877.—The collections in entomology have been greatly increased during the past year, chiefly through voluntary contributions of the scientific expedition to Colorado in the summer of 1876. The cabinets now include upwards of 3000 species of Kansas insects.

Donations:

By Prof. F. H. Snow: 6000 Colorado insects.
By Geo. F. Gaumer: 900 Colorado insects.
By Elmer B. Tucker: 400 Colorado insects.
By Charles W. Smith: 300 Colorado insects.

In the summer of this year Professor Snow and two students, Richard Foster and John H. Walker, made an expedition to Wallace county, where they collected about 1500 specimens of the then rare tiger beetle *Amblychila cylindriformis*, and reduced the market price of these specimens from $15 to $1.

1878.—The entomological collection contains more than 5000 species, representing all the different orders of insects. They are of practical value to the agricultural and horticultural interests of the state, as well as to the students of the University, in the determination of the names and habits of our insect friends and foes.

Donations:

By Geo. F. Gaumer: All the duplicates of his collection of Diptera, about 1000 specimens.

By Prof. F. H. Snow: 3000 Kansas insects and plants.

During August Professor Snow, with Richard Foster and L. L. Dyche, two students in the University, made a trip into Colorado to "Dome Rock," Platte canyon, where they collected insects.

1879.—The entomological collections contain more than 6000 species, representing all the different orders of insects.

Professor Snow, with his family and two student assistants, Miss Annie Mosley and L. L. Dyche, made another trip to Colorado and camped for six weeks near Idaho Springs. They secured a fine collection of butterflies and moths.

1880.—The entomological collections contain more than 7000 species, representing all the different orders of insects.

Donations:

By Lewis L. Dyche: Collection of Colorado Lepidoptera, about 1000 specimens.

By W. G. Raymond: 148 species of Kansas Coleoptera.

Professor Snow and the same party of 1879 went to Santa Fe canon, New Mexico, and in four weeks they collected 237 species and varieties of Coleoptera, many of them new to science and rare, and also many other insects.

1881.—The entomological collections contain more than 8000 species, representing all of the different orders of insects.

Donations:

By J. C. Cooper, Esq., Topeka: Extensive and valuable entomological collections made by his son, the late Geo. P. Cooper.

Professor Snow, with Prof. H. H. S. Smith of the physics department, and Professor Snow's son Willie, and L. L. Dyche, made a trip into New Mexico to the Magdalena mountains, collecting insects.

1882.—The entomological collections contain more than 10,000 species, representing all of the different orders of insects.

Professor Snow, his family, and three students of the University, W. W. Russ, Miss Mary Dyche, and L. L. Dyche, spent nine weeks near the Las Vegas Hot Springs, New Mexico. A general collection of insects was made.

1883.—The entomological collections of the University contain more than 10,000 species. These have been greatly increased during the last few years by the voluntary contributions of the exploring parties in western Kansas, Colorado, and New Mexico By means of the material thus accumulated, a system of exchanges has been established with leading institutions and naturalists in all parts of the United

States, so that the cabinets contain a very satisfactory representation of the insects not only of the state of Kansas, but also of the whole of North America.

Donations:

By Frank Thompson: Collection of beetles from Mexico.

By Doctor Fritz Gærtner: A collection of Lepidoptera from Honduras.

By J. C. Cooper, Esq., Topeka: A collection of Coleoptera from western Kansas and Colorado.

By L. L. Dyche: Insects from New Mexico.

Doctor Snow, with three students of the University, W. H. Brown, W. C. Stevens, and L. L. Dyche, made an expedition to the same locality as in 1882, collecting insects.

1884.—This year the collecting party, which again visited New Mexico, was divided into two sections. Professor Snow, W. C. Stevens and Willie Snow collected on Walnut creek, near Silver City; and L. L. Dyche and W. H. Brown collected part of the time on Baldy mountain and the rest of it on the headwaters of the Pecos river.

1885.—Donations:

By W. H. Brown and W. C. Stevens: New Mexican insects.

Appropriation of $50,000 by the legislature for the erection of a building on the University grounds for use of the department of natural history.

1887.—Donation:

By M. Braverman: An alcoholic collection of California insects.

1888.—Donations:

By Ed. Graham: Entomological specimens.

By W. R. Cone: A collection of insects from California.

1889.—Donations:

By Prof. L. L. Dyche: A collection of Kansas insects.

By Mrs. L. L. Dyche: A collection of New Mexico Coleoptera.

By J. N. Scott, Joseph Thoburn, M. E. Hickey, and W. E. Brewer: An extensive collection of cocoons and silk products from the state silk station at Peabody, Kan.

By V. L. Kellogg: A set of 25 microscope slides, illustrating the genera and species of Mallophaga.

By Miss Gertrude Crotty: A collection of Coffey county Orthoptera.

Professor Snow made a collecting trip to Estes Park, Colorado.

1890.—Donations:

By W. G. Smith: A collection of Colorado insects.

Professor Snow made a collecting trip to Bailey, Platte canyon, Colorado.

1891.—Donations:

By H. R. Linville, Ness City: Collection of locusts from Ness county.

By H. P. Krehbiel: Specimens of burrowing bees and nests of same.

Professor Snow made a collecting trip to Manitou Park, Colorado.

1892.—Professor Snow made a collecting trip to Estes Park, Colorado.

1894.—Donations:

By W. A. Snow: 2000 Illinois Diptera.

By Prof. L. Bruner, Lincoln, Neb.: Rare Nebraska Diptera.

By S. W. Williston: Collection of Nevada Diptera.

By Dr. S. W. Williston: Collection of Diptera, Douglas county; 20 types of new species of North American Diptera.

By C. Faulkner, Atchison, Kan.: 300 species of Kansas Microdiptera.

By Prof. J. M. Aldrich, Moscow, Idaho: Diptera from South Dakota and elsewhere, with types of new species.

By Dr. Geo. F. Gaumer: 1000 specimens of United States Diptera; 5000 Yucatan insects.

By Nathan Banks, Sea Cliff, N. Y.: Neuroptera and Diptera from New York.

By C. W. Johnson, Philadelphia: 100 specimens of Diptera from eastern United States.

Doctor Snow made a collecting trip to the Magdalena mountains, New Mexico.

1896.—S. J. Hunter went to western Kansas to make a study of the grasshopper problem, and collected insect specimens amounting to about 10,000 specimens.

1897.—Professor Snow made a collecting trip to Estes Park, Colorado.

1898.—Professor Hunter conducted a collecting expedition to western Kansas.

1899.—Professor Hunter conducted a collecting expedition to western Kansas.

1900.—Professor Hunter collected on the Atlantic coast.

1902.—Doctor Snow conducted a collecting expedition to Hamilton and Morton counties, Kansas.

Doctor Snow also made a collecting trip to Oak Creek canyon, and Humphrey's Peak, Arizona.

1903.—Doctor Snow conducted a collecting expedition to Clark county, Kansas.

Doctor Snow also conducted a collecting expedition to Martinez, or Congress Junction, and Williams Fork of Colorado river.

1904.—Doctor Snow, with his regular assistant, Mr. E. F. Tucker, and Dr. C. F. Adams spent three weeks at Galveston, Tex., making a general collection of insects.

Doctor Snow also visited Oak Creek canyon, Coconino county, Arizona, being assisted by Prof. W. H. Johnson and two students, Eugene Smythe and Judah Drisco.

1905.—Doctor Snow spent a month at Brownsville, Tex., and was assisted by Mr. Tucker and an undergraduate student, Mr. E. G. Corwine.

Later this same summer Doctor Snow, Eugene Smythe, Ebb. Crumb and Rollin Perkins spent five weeks at San Bernardino ranch, on Sycamore creek, Cochise county, Arizona.

1906.—Doctor Snow, assisted by L. A. Adams, S. E. Crumb and Eugene Smyth, spent June and July in Pima county, Arizona, making a general collection of insects.

1907.—Doctor Snow made his last collecting trip to the Santa Rita mountains, Arizona. He was assisted on this expedition by W. J. Baumgartner, W. R. B. Robertson, Fred Farragher, and Eugene Smythe.

1908.—By act of the board of regents, the collections were called "The Francis Huntington Snow Entomological Collections," in acknowledgment of the work done by Doctor Snow.

1909.—A valuable collection of exotic Coleoptera and Lepidoptera was added, part donated by Miss Barteldes, part by Mr. Sedgwick.

1910.—Mr. Francis X. Williams, of Leland Stanford University, was appointed assistant curator of the entomological collection.

Mr. F. X. Williams conducted a party, consisting of Messrs. Slagle, Bradbury and Hungerford, into northwestern Kansas, and made a biological and systematic survey of thirteen counties, and brought back 30,000 specimens.

1911.—Mr. F. X. Williams and Messrs. Lockwood, Lovejoy and Ray Miller spent the whole of the summer in southwestern Kansas, continuing the systematic survey and collecting specimens, and brought back 25,000 specimens.

1912.—Mr. F. X. Williams and a party consisting of Messrs. Isely, Mallory, O'Roke and Jennings spent the summer in the eastern half of the northwestern quarter of Kansas, continuing the systematic survey and bringing back a large number of specimens.

1913.—Professor Hunter, the curator, Assistant Professor Hungerford, Mr. Collett, fellow, and Mr. Vansell, assistant, made up the expedition which collected along Rock river, Wyoming, and Beaver creek, Montana.

SCIENTIFIC EXPEDITIONS OF THE ENTOMOLOGICAL MUSEUM OF THE UNIVERSITY OF KANSAS FROM 1876 TO THE PRESENT TIME.

1876.—Colorado Springs and Pike's Peak, Colorado.
1877.—Wallace county, Kansas.
1878.—Gove county, Kansas.
1879.—"Dome Rock," Platte canyon, Colorado.
1879.—Idaho Springs, Colorado.
1880.—Santa Fe canyon, New Mexico.
1881.—Magdalena mountains, twenty-five miles west of Socorro.
1882.—Las Vegas Hot Springs, New Mexico.
1883.—Gallinas canyon, near Las Vegas Hot Springs, New Mexico.
1884.—New Mexico.
1889.—Estes Park, Colorado.
1890.—Bailey, Platte canyon, Colorado.
1891.—Manitou Park, Colorado.
1892.—Estes Park, Colorado.
1894.—Magdalena mountains, New Mexico.
1897.—Estes Park, Colorado; Edwards, Finney, and Hamilton counties, Kansas.
1898.—Hamilton, Wallace and Greeley counties, Kansas.
1899.—Cheyenne and Sherman counties, Kansas.
1900.—Woods Hole, Massachusetts.
1901.—Buzzard's Bay.
1902.—Hamilton and Morton counties, Kansas.
1902.—Oak Creek canyon and Humphrey's Peak, Arizona.
1903.—Clark county, Kansas.
1903.—Martinez, or Congress Junction, and Williams Fork of Colorado river.
1904.—Galveston, Texas.
1904.—Oak Creek canyon, Coconino, Arizona.
1905.—Brownsville, Texas; San Bernardino ranch, on Sycamore creek, Cochise county, Arizona.
1906.—Pima county, Arizona.
1907.—Santa Rita mountains, Arizona.
1910.—Gove, Logan, Sheridan, Rawlins, Decatur, Thomas, Cheyenne, Sherman, Wallace, Greeley, Wichita, Scott, and Lane counties, Kansas.
1911.—Pratt, Kiowa, Meade, Haskell, Grant, Stanton, Morton, Stevens, Seward and Clark counties, Kansas.
1912.—Barton, Rush, Ness, Trego, Ellis, Russell, Osborne, Rooks, Graham, Norton, Phillips, and Smith counties, Kansas.
1913.—Rock river, Wyoming; Beaver creek, Montana.

INSECT TYPES AND COTYPES IN ENTOMOLOGICAL MUSEUM.

ORDER NEUROPTERA.

Hemerobidæ.

Glenuyus snowii Banks.

ORDER ORTHOPTERA.

Mantidæ.

Stagomantis gracilipes Rehn.

Tryxalinæ.

Cordillacris pima Rehn.

Œdipodinæ.

Lactista arphoides Rehn.
Trimerotropis snowii Rehn.

Acridiinæ.

Melanoplus blatchleyi Scudd.
bruneri Scudd.
gladstoni Brunn.
intermedius Brunn.
snowi Scudd.

Locustidæ.

Ceuthophilus tuckeri Rehn.
Plagiostira gracilis Rehn.
Ceutophilus paucispinosa Rehn.
Phrixocnemis franciscanus Rehn.
Phrixocnemis socorrensis Rehn.
Udeopsylla serrata Rehn.

ORDER HEMIPTERA.—HETEROPTERA.

Coreidæ.

Alydus setosus V. D.

Berytidæ.

Jalysus wickhami V. D.

Capsidæ.

Xestocrus nitens Reut.
Diaphnidia debilis Uhl.
Orthoptylus translucens Tucker.
Oncotylus sericatus Uhl.

Tingitidæ.

Corythuca pergandei Heid.

ORDER HEMIPTERA.—HOMOPTERA.

Coccidæ.

Aspidiotus fernaldi ckll. var. albiventer Hunter.
æsculi Johns. sub. sp. solus Hunter.
Diaspis snowii Hunter.
Lecanium kansasense Hunter.
aurantiacum Hunter.
cockerelli Hunter.
Lecaniodiaspis (?) parrotti.

ORDER HEMIPTERA.—HOMOPTERA.

Fulgoridæ.

Scolopsella reticulata Ball.
Oecleus snowii Ball.

Bythoscopidæ.

Pediopsis erythrocephalus G. & B.
Idiocerus snowii G. & Pr.
perplexus G. & B.
rufus G. & B.
Agallia gillctei O. & B.

Jassidæ.

Memnoinia consobrina Ball.
fraterna Ball.
Parabolocratus brunneus Ball.
Deltocephalus flexuosus Ball.
Athysanus alpinus Ball.
Eutettix scitula Ball.
insana Ball.
striata Ball.
texana Ball.
snowi Ball.
osborni Ball.
Phlepsius graphicus Ball.
cumulatus Ball.
denudatus Ball.
turpiculus Ball.
Scaphoideus blandus Ball.
Lonatura noctuaga Ball.
salsura Ball.
Thamnotettix cockerelli Ball.
osborni Ball.
Empoasca atrolabes Gill.
unicolor Gill.
alboneura Gill.
nigroscuta G. & B.

ORDER COLEOPTERA.

Elateridæ.

Cardiophorus arizonensis Fall.

Cleridæ.

Cymatodera arizonæ Wolcott..
subsimilis Wolcott.
Clerus snowi Wolcott.
bioculatus Skinner.
Hydnocera ornata Wolcott.
cæruleipennis Wolcott.

Scarabeidæ.

Ochodaeus kansanus Fall.

Cerambycidæ.

Leptostylus yuceæ Fall.

Chrysomelidæ.

Pachybrachys notatus Bow.
discolor Bow.

Meloidæ.

Hornia? gigantea Wellman.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Tipulidæ.

Eriocera eriophora Will.
obscura Will.
Rhaphidolabis debilis Will.
Tipula acuta Doane.
dorsimacula Walker.
dorsolineata Doane.
retusa Doane.
unincineta Doane.
spectabilis Doane.
streptocera Doane.
sulphurea Doane.

Psychodidæ.

Psychoda slossoni Will.

Chironomidæ.

Tersesthes torrens Towns.
Ceratopogon dimidiatus Adams.
flavus Will.
Chironomus anonymus Will.
flaviventris Johan.
longimanus Will.
lucifer Johan.
microcerus Will.
Alabesmyia aurea Johan.

Culicidæ.

Culex affinis Adams.
apicalis Adams.
particeps Adams.

Mycetophilidæ.

Ceroplatus apicalis Adams.
Platynura gracilis Will.
notabilis Will.
pulchra Will.
Sciophila angulata Adams.
nigricauda Adams.
Syntemna mutor Adams.
Neoglaphyroptera cuneola Adams.
lineola Adams.
striata Will.
Macrocera diluta Adams.
Eugnoriste occidentalis Coq.

Cecidomyidæ.

Asphondylia atriplicis Towns.
Cecidomyia raditæ Snow.

Simuliidæ.

Simulium argus Will.
notatum Adams.

Stratiomydæ.

Scoliopelta luteipes Will.
Hermetia comstocki Will.
eiseni Towns.
Ptecticus sackeni Will.
Chrysochroma albipes Towns.
Macrosargus clavis Will.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Stratiomydæ—continued.

Odontomyia americana Day.
flava Day.
pilosa Day.
pubescens Day.
Euparyphus albipilosus Adams.
limboventris Will.
mutabilis Adams.
ornatus Will.
septemmaculatus Adams.
Clitellaria argentata Will.
Nemotelus abdominalis Adams.
bruesii Mel.
kansensis Adams.
trinotatus Mel.

Tabanidæ.

Pangonia dives Will.
fera Will.
Silvius pollinosus Will.
Chrysops bistellatus Daeck.
discalis Will.
frazari Will.
pachyceras Will.
Chrysops pertinax Will.
sequax Will.
Tabanus baal Towns.
fenestra Will.
fratellus Will.
fur Will.
guttatues Towns.
hyalinipennis Hine.
laticeps Hine.
osborni Hine.
parvulus Will.
productus Hine.
pygmæus Will.
sodalis Will.
Snowiellus atratus Hine.

Leptidæ.

Xylophagus decorus Will.
gracilis Will.
nitidus Adams.
Xylomyia parens Will.
Arthroceras pollinosum Will.
Leptis palpalis Adams.
pleuralis Adams.
Chrysopila bella Adams.
flavibarbis Adams.
lucifera Adams.
Symphoromyia flavipalpis, Adams.
pachyceras Will.
plangens Will.

Nemestrinidæ.

Hirmoneura flavipes Will.
Rhynchocephalus sackeni Will.
volaticus Will.

Cyrtidæ.

Acrocera liturata Will.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Bombylidæ.

Anthrax aemulus O. S.
agrippina O. S.
alta Tucker.
comparata Tucker.
cuniculus O. S.
faustina O. S.
livia O. S.
moneta O. S.
sabina O. S.
Triplasius novus Will.
Heterostylum sackeni Will.
Anastoechus melanobalteralis Tucker.
fulvipennis Tucker.
melanobalteralis var.
Lordotus pulcherrimus Will.
Eclimus auratus Will.
lotus Will.
melanosus Will.
sodalis Will.
Desmatoneura argentifrons Will.
Aphœbantus carbonarius O. S.
conurus O. S.
cyclops O. S.
Desmatomyia anomala Will.
Dolichomyia gracilis Will.

Thereridæ.

Psilocephala acuta Adams.
lateralis Adams.
occipitalis Adams.
Thereva anomala Adams.
crassicornis Will.

Scenopinidæ.

Scenopinus electa Adams.
mirabilis Adams.

Mydaidæ.

Ectypus townsendi Will.
luteolus Will.
Mydas abdominalis Adams.
scitulus Will.

Apioceridæ.

Rhaphiomydas mellifex Towns.
xanthos Towns.

Asilidæ.

Stenopogon aeacidinus Will.
Triclis tagax Will.
Myelaphus rufus Will.
Dioctria pusio O. S.
nitida Will.
sackeni Will.
Cyrtopogon dasyllis Will.
dubius Will.
?gibber Will.
præpes Will.
Lasiopogon terricola Johnson.
Holopogon snowii.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Asilidæ—continued.

Saropogon albifrons Black.
Deromyia perplexa M. A. C.
Taracticus brevicornis Will.
Cophura? breviconis Will.
fur Will.
scitula Will.
Atonia mikii Will.
Nicocles abdominalis Will.
rufus Will.
Nusa chalybea Will.
Laphria canis Will.
carbonarius Will.
ferox Will.
pubescens Will.
ruficauda Will.
ventralis Will.
vivax Will.
xanthippe Will.
Ommatius nigromaculosus Back.
Proctacanthus arno Towns.
Erax dubius Will.
jubatus Will.
latrunculus Will.
leucocomus Will.
similis Will
stamineus Will.
varipes Will.
Mallophora guildiana Will.
Promachus albifaces Will.
princeps Will.
rufipes Fabr.
Stenoprosopus arizonensis Will.
Neoitamus affinis Will.
distinctus Will.
Tolmerus delusus Tucker.
callidus Will.
mesæ Tucker.
Philodicus rufipennis Hine.
Asilus angustifrons Will.
astutus Will.
Rhadiurgus leucopogon Will.

Dolichopodidæ.

Psilopodinus insularis Ald.
Diaphorus contiguus Ald.
dubius Ald.
flavipes Ald.
simplex Ald.
spectabilis Loew.
Asyndetus fratellus Ald.
Chrysotus albipalpus Ald.
excisus Ald.
hirsutus Ald.
niger Ald.
proximus Ald.
Eutarsus sinuatus Ald.
Parasyntormon occidentale Ald.
Sympycnus frater Ald.
Anepsiomyia linearis Ald.
Neurigona lateralis Say.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Dolichopodidæ—continued.

Thinophilus pectinifer Wheeler.
Thrypticus cupuliferus Ald.
singularis Ald.
Hydrophorus canescens Wheeler.
Liancalus hydrophilus Ald.
similis Ald.
Dolichopus albicoxa Ald.
ciliatus Ald
coloradensis Ald.
convergens Ald.
dakotensis Ald.
duplicatus Ald.
grandis Ald.
angustatus Ald.
idahoensis Ald.
kansensis Ald.
marginatus Ald.
obcordatus Ald.
occidentalis Ald.
plumosus Ald.
tenuipes Ald.
vigilans Ald.
willistonii Ald.
Herocostomus latipes Ald.
Paraclius filifer Ald.
venustus Ald.
Sarcionus lineatus Ald.
Pelastoneurus argentifer Ald.
kansensis Ald.

Empididæ.

Drapetis flavida Will.
flaviceps Will.
Paraxhalassius aldrichi Mel.
Thinodromia inchoata Mel.
Hilara nugax Mel.
Rhamphomyia sociabilis Will.

Phoridæ.

Aphiochæta halictorum Mel. & Brues.

Platypezidæ.

Callimyia venusta Loew.
Calotarsa calceata Snow.
ornatipes Towns.
Platypeza abscondita Snow.
cinerea Snow.
pulchra Snow.
tæniata Snow.
umbrosa Snow.
unicolor Snow.

Pipunculidæ.

Pipunculus fuscitaris Adams.

Syrphidæ.

Microdon lanceolatus Adams.
melgaogaster Snow.
pallipennis Snow.
violens Towns.
xanthophilus Towns.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Syrphidæ—continued.

Callicera montensis Snow.
Nausigaster scutellaris Adams.
Chilosia chalybescens Will.
lucta Snow.
nigripennis Will.
tarda Snow.
willistonii Snow.
Baccha bella Will.
Platychirus palmulosus Snow.
Melanostoma cœrulescens Will.
concinnum Snow.
kelloggi Snow.
Syrphus creper Snow.
disgregus Snow.
montivagus Snow.
pullulus Snow.
ruficauda Snow.
Xanthogramma habilis Snow.
Sphærophoria melanosa Will.
Brachyopa cynops Snow.
Volucella apicifera Towns.
Eristalis montanus Will.
Tropidia incana Towns.
Helophilus dychei Will.
Mallota albipilis Snow.
Criorhina lupina Will.
Spilomyia kahlii Snow.
Ceria snowi Adams.
townsendii Snow.

Conopidæ.

Conops bellus Adams.
fronto Will.
sylvosus Will.
gracilis Will.
xanthopareus Will.
Physocephala affinis Will.
burgessi Will.
furcillata Will.
Zodion albitus Adams.
bicolor Adams.
parvum Adams.
pictulum Will.
pygmæum Will.
scapulare Will.
Stylogaster neglecta Will.
Dalmannia picta Will.
Oncomyia baroni Will.
modesta Will.
modesta, var. melanopoda Will.
propinqua Adams.
Myopa pictipennis Will.
pilosa Will.
plebeia Will.
tectura Adams.

Tachinidæ.

Cistogaster pallasii Towns.
Phorantha occidentis Walk.
Alophora æneoventris Will.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Tachinidæ—continued.

Euscopolia dakotensis Towns.
Trichopoda subcilipes Towns.
Ceratomyiella conica Towns.
Rhinophora mexicana Towns.
valida Towns.
Anisia vanderwulpi Towns.
Euryceromyia robertsonii Towns.
Hypostena floridensis Towns.
indecisa Towns.
vanderwulpi Towns.
Hyalurgus johnsoni Towns.
Polidea americana Towns.
Eumyothyria illinoisensis Towns.
Leucostoma atra Towns.
neomexicana Towns.
senilis Towns.
Clytiomyia flava Towns.
Wahlbergia atripennis Towns.
Epigrymyia floridensis Towns.
geniculata Towns.
lucens Towns.
polita Towns.
robertsonii Towns.
Ginglymyia acrirostris Towns.
Plagiprospherysa floridensis Towns.
valida Towns.
Plagia aurifrons Towns.
Siphoplagia anomala Towns.
Goniochæta plagioides Towns.
Chætoglossa picticornis Towns.
violæ Towns.
Pachyophthalmus aurifrons Towns.
floridensis Towns.
Pseudotractocera neomexicana Towns.
Belvosia vanderwulpi Will.
Malanophrys flavipennis Will.
Aphria ocypterata Towns.
Ocyptera argentea Towns.
Nemoræa hyphantriæ Towns.
nigricornis Towns.
Gymnochæta ruficornis Will.
vivida Will.
Hyphantrophaga hyphantriæ Towns.
Exorista eudryadis Towns.
lagoæ Towns.
plagioides Towns.
Euphorocera tachinomoides Towns.
Phorocera comstocki Will.
lophyri Towns.
puer Will.
Hypertrophocera parvipes Towns.
Frontina archippivora Will.
frenchii Will.
Sturmia nigrita Towns.
Masicera eufitchiæ Towns.
exilis Coq.
hemarides Towns.
Prospherysa promiscua Towns.
websterii Towns.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Tachinidæ—continued.

Vanderwulpia atrophopodoides Towns.
sequens Towns.
Tachina flavidensis Towns.
spinulosa Towns.
robusta Towns.
Dæochæta harveyi Towns.
Neotractocera anomala Towns.
Paraphyto gillettei Towns.
Blepharipeza nigrisquamis Towns.
rufescens Towns.
Muscopteryx chætosula Towns.
Paradidyma braueri Will.
singularis Towns.
Atrophopalpus angusticornis Towns.
Phorichæta sequax Will.
Metopia luggeri Towns.
Hilarella decens Towns.
elita Towns.
polita Towns.
Brachycoma chihuahuaensis Towns.
intermedia Towns.
sarcophagina Towns.
Euthyrosopa petiolata Towns.
Gonia porca Will.
exul Will.
senilis Will.
sequax Will.
Spallanzania finitima Snow.
Cnephalia pansa Snow.
Eucnephalia gonoides Towns.
Amobia distincta Towns.
Archytas hystricoides Will.
Echinomyia dakotensis Will.
hystricosa Will.
Epalpus bicolor Will.
maculatus Will.
signiferus Wlk.
Jurinella exilis Towns.
soror Will.

Dexiidæ.

Hystrichodexia roederi Will.
Melanodexia tristis Will.

Sarcophagidæ.

Sarcophaga chætopygialis Will.
cimbicis Towns.
concinnata Towns.
helicis Towns.
leucaniæ Towns.
micropygialis Will.
(Tephromyia) hunteri Hough.
Sarcodexia sternodontis Towns.

Musicidæ.

Chrysomyia desvoidyi Hough.
Morellia nigricosta Hough. (S. Am.)
Hæmatobia alcis Snow.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Borboridæ.

Aptilotus politus Will.
Limosina exigua Adams.
evanescens Tucker.
setigera Adams.

Sciomyzidæ.

Tetanocera inopa Adams.

Sapromyzidæ.

Pachycerina dolorosa Will.
Sapromyza ingrata Will.
octovittata Will.
polita Will.
puella Will.
sororia Will.

Ortalidæ.

Rivellia brevifasciata Johnson.
Euxesta apicalis Will.

Trypetidæ.

Spilographa diffusa Snow.
Trypeta occidentalis Snow.
Polymorphomyia basilica Snow.
Œdaspis minuta Snow.
montana Snow.
Rhagoletis zephyria Snow.
Eutreta longicornis Snow.
Eurosta fenestrata Snow.
reticulata Snow.
Xenochæta dichromata Snow.
Icterica fasciata Adams.
Tephritis dupla Cress.
pallidipennis Cress.
obscuripennis Snow.
variabilis Doane.
Euaresta bellula Snow.
latipennis.
Urellia conjuncta Adams.
flava Adams.
occidentalis Adams.

Micropezidæ.

Micropeza turcana Towns.
Calobata pleuritica Johnson.

Ephydridæ.

Notiphila decoris Will.
Paralimna multipunctata Will.
obscura Will.
Discomyza dubia Will.
Discocerina obscura Will.
Ochtheroidea atra Will.
Ephydra pygmæa Will.
tarsata Will.

ORDER DIPTERA. (NORTH AMERICAN LIST.)

Oscinidæ.

Chlorops albifacies Adams.
appropinqua Adams.
bilineata Adams.
cinereipennis Adams.
halteralis Adams.
ingrata Will.
liturata Adams.
parva Adams.
recurva Adams.
rubicunda Adams.
Hippelates splendens Adams.
Elachiptera bilineata Adams.
Oscinis collusor Towns.
incipiens Will.

Drosophilidæ.

Drosophila coffeata Will.
ornatipennis Will.
pallida Will.

Agromyzidæ.

Agromyza lateralis Will.
sorosis Will.
Opthalmomyia lacteipennis Loew.
lobioptera Will.

Hippoboscidæ.

Trichobius dugesii Towns.

Nycteribiidæ.

Nycteribia antrozoi Towns.

ORDER LEPIDOPTERA.

Hesperidæ.

Pyrgus nessus Edw. (Cotype.)
polingii Barnes.
occidentalis Skinner.
Heteropia melon, var. arizonensis Skinner.
Megathymus polingii Skinner.

Saturniidæ.

Hyperchiria zephyria Grt.

Syntomidæ.

Cosmosoma rubrogutta Skinner.
Syntomeida befana Skinner.
Scepsis packardii, var. cockleri Dyar.

Lithosiidæ.

Ruscino arida Skinner.

Arctiidæ.

Alexicles aspersa Grt.
Pygoctenucha funerea Grt.
Hemihyalea labecula Grt.
Bertholdia trigona Grt.

ORDER LEPIDOPTERA.

Noctuidæ.

Cyathissa quadrata Sm.
Perigaea morsa Smith.
Hadena burgessi Morr.
Oncocnemis major Grt.
Acopa perpallida Grt.
Aleptina flavomedia Sm.
Rhynchagrotis minimalis Grt.
bimarginalis Grt.
mirabilis Grt.
Peridroma grandipennis Grt.
Noctua conchis Grt.
beata Grt.
Chorizagrotis terrealis Grt.
Feltia circumdata Grt.
Porosagrotis catenula Grt.
Euoxa olivalis Grt.
ura Sm.
flavidens Sm.
cænis Grt.
munis Grt.
infausta Wlk., var. rufula Sm.
verticalis Grt.
basalis Grt.
anacosta Sm.
Richia parentalis Grt.
decipiens Grt.
distichoides Grt.
Mamestra prodeniformis Sm.
artesta Sm.
arida Sm.
æsculi Sm.
Barathra occidenta Grt.
Trichorthosia parallella Grt.
Anarta mimula Grt.
Hydroecia juvenalis Grt.
Pyrrhia stilla Grt.
Heliothis suavis Hy. Edw.
Rhodosea julia Grt.
Rhododipsa mimana. Grt.
Grotella dis Grt.
Bessula luxa Grt.
Autographa snowi Hy. Edw.
Marasmalus inficita Wlk., var. histrio Grt.
Eucalyptra gigantea Grt.
Excaria clauda Grt.
Metoponia nanata Neum.
Minofala instans Sm.
Homopyralis miserulata Grt.
cinctus Sm.
Euclidia intercalaris Grt.
Caliptera bucetum Grt.
Renia rigida Sm.
Hypenula cominalis Sm.
Palthis albisinuatus Sm.
Rhescipha snowi Skinner.

Lasiocampidæ.

Gloveria diasoma Grt.

ORDER LEPIDOPTERA.

Geometridæ.

Cœnocalpe fervifactaria Grt.
formosata Strck.
Emplocia inconstans Geyer.
Fernaldella stalachtaria Strck., var. alternaria Grt.
Deilinia elimaria Hulst.
perpallidaria Grt.
Sciagraphia cruciata Grt.
Caripeta equalaria Grt.
Glaucina puellaria Dyar.
Phæoura mexicanaria Grt.
Eucaterva variaria Grt.
(var.) sabesaria Grt.
Lychnosea helveolaria Hulst.
Therina vitraria Grt.
Hyperitis indiscretata Hy. Edw.
Metanema excelsa Strck., var. simpliciaria Grt.
Sabulodes sulphurata imitata Hy. Edw.
catenulata Grt.

Sesiidæ.

Melittia snowii Hy. Edw.

Pyralidæ.

Symphysa simplicialis Kearf.
Evergestis obliquilis Grt.
Elophila avernalis Grt.
Prionapteryx baboquinariella Kearf.
Crambus dimidiatellus Grt.
Dioryctria aurantiacella Grt.

Tortricidæ.

Proteoteras arizonæ Kearf.
Epinotia snowiana Kearf.

Yponomeutidæ.

Plutella yumaella Kearf.

Blastobasidæ.

Holocera arizoniella Kearf.

Tineidæ.

Trichophaga crescentella Kearf.

ORDER HYMENOPTERA.

Tenthredinidæ.

Hylotoma conspiculata MacG.

Evaniidæ.

Hyptia texana Brad.

Ichneumonidæ.

Ichneumon arizonensis Vier.
egregiafascialis Vier.
citrinifacialis Vier.
flavicornis Cress.
varriola Cres.
oryxiocornis Vier.

Order HYMENOPTERA.

Ichneumonidæ—continued.

Ichneumon nigrosignatus Vier.
hemimelanarius Vier.
humphreyi Vier.
flavofascialis Vier.
(Barichneumon) flavofascialis Vier.
maurus Cress.
Syndipnus erythrogaster Vier.
Platylabus omniferrugineus Vier.
Phygadeuon oryxicornis Vier.
spinicoxus Vier.
Cryptus citrinimaculatus Vier.
consobrinus Vier.
politicalypterus Vier.
Nematopodius exclamans Vier.
Mesostenus discoidaloides Vier.
Hemiteles manitouensis Vier.
laphroscopoides Vier.
Pezomachus homalommoides Vier.
testaceicoxus Vier.
alogus Vier.
Ophion idoneum Vier.
Eremotylus felti Vier.
Thyreodon morio Fabr., var. transitionalis Vier.
snowi Vier.
Nototrachys reticulatus Cress.
Anomalon fulvescens, var. hemimelas Vier.
pæneferrugineum Vier.
Atrometus angitioides Vier.
Campoplex photomorphus Vier.
wyomingensis Vier.
Limnerium lawrencei Vier.
vigile Vier.
perdistinctum Vier.
Idechthis biconjunctus Vier.
pænerivalis Vier.
Amorphota perrivalis Vier.
pænexareolata Vier.
confluens Vier.
confluens Vier., mutation a.
confluens Vier., mutation b.
confluens Vier., mutation c.
augusta Vier.
galvestonensis Vier.
nocturna Vier.
relativa Vier.
ferruginosa Vier.
autumnalis Vier.
Ischnoscopus tæniatus Vier.
Angitia autumnalis Vier.
Mesochorus noctivagus Vier.
Olesicampa melanerythrogastra Vier.
Thersilochus hamiltonensis Vier.
snowi Vier.
egregiacolor Vier.
mimeticus Vier.
quintilis Vier.
Metopius grandior Vier.
Bœthus ænigmaticus Vier.

ORDER HYMENOPTERA.

Ichneumonidæ—continued.

Synchnoporthus tuckeri Vier.
Callidiotes kansensis Brues.
Scopiarius monticola Brues.
Agathobanchus bradleyi Vier.
Pimpla parvialba Vier.
    landerensis Vier.
Glypta aprilis Vier.
    brunneisigna Vier.
    egregiafovea Vier.
    succincipennis Vier.
Arenetra leucotænia Vier.
Pristomerus appalachianus Vier.
    appalachianus, var. dorsocastaneus Vier.
Harrimaniella pæneimitatrix Vier.
Lampronota occidentalis Cress.

Braconidæ.

Bracon kansensis Vier.
    piceipes Vier.
Lysiphlebus succineus Vier.
Melanobracon ulmicola Vier.
Vipio erythrus Vier.
    piceipectus Vier.
Rhogas fuscicaudus Vier.
    melanothorax Vier.
    cockerelli Vier.
Chelonus altitudinis Vier.
    egregicolor Vier.
    exogyrus Vier.
    nucleolus Vier.
    texanoides Vier.
Microgaster tuckeri Vier.
Diachasma appalachicola Vier.
    secunda Vier.
Boisteres indotatus Vier.
Ichneutidea preteroptoides Vier.
Cardiochiles nigroclypeus Vier.
Ascogaster mimeticus Vier.
Agathis wyomingensis Vier.
Microdus agathoides Vier.
    nigrotrochantericus Vier.
    pimploides Vier.
    castaneicinctus Vier.
    wichitanensis Vier.
Crassomicrodus nigricaudus Vier.
Lytopylus azygos Vier.
Meteorus campestris Vier.
    relativus Vier.
    noctivagus Vier.
Dinotrema signifrons Vier.
Brachistes nocturnus Vier.
Zele crassicalcaratus Vier.
Cœnocelius politifrons Vier.
Iphiaulax perepicus Vier.
    propinquus Vier.
    militaris Vier.
    melanogaster Vier.
    cinnabarinus Vier.
    triangulifera Vier.

ORDER HYMENOPTERA.

Braconidæ—continued.

Opius aberrans Vier.
basiniger Vier.
luteiceps Vier.
nigrocastaneus Vier.
Aphaereta delosa Vier.
subtricarinata Vier.
Aspilota columbiana Vier.
Hormiopterus claripennis Brues.
Phaenodus caddous Vier.
Hedysomus wichitus.
Doryctes femur-rubrum Vier.
apacheus Vier.
Doryctomorpha shoshonea Vier.

Chalcididæ.

Leucospis bicincta Vier.

(*Proctotrupidæ*) *Serphidæ.*

Scelio monticola Brues.
striaticollis Brues.
venata Brues.

Chrysididæ.

Notozus connexus Vier.
Chrysis equidens Vier.
kahli Vier.
kansensis Vier.
petronella Vier.
snowi Vier.

Mutillidæ.

Mutilla crepuscula Vier.
nigricauda Vier.
prognoides Vier.
apachea Vier.
montivagoides Vier.
quintilis Vier.
imperialiformis Vier.
Brachycystis stictinotus Vier.

Scoliidæ.

Elis pollenifera Vier.
pollenifera Vier, var. A. Vier.

(*Pompilidæ*) *Psammocharidæ.*

Anoplius snowi Vier.
Cryptochelius pæneparcus Vier.
Aporus ferrugineipes Vier.
Pepsis angustimarginata Vier.

Sphecidæ.

Sphex ashmeadi Fernald.
Parasphex ferrugineus Fox.

Larridæ.

Larropsis minor Williams.
ater Williams.
pænerugosa Vier.
tachysphecoides Vier.
vegetoides Vier.
zerbeii Vier.

ORDER HYMENOPTERA.

Larridæ—continued.

Tachysphex clarkonis Vier.
crassiformis Vier.
robusterior Williams.
consimiloides Williams.
sculptiloides Williams.
nigrocaudatus Williams.
plenoculiformis Williams.
crenuloides Williams.
dentatus Williams.
sepuleralis Williams.
glabrior Williams.
Tachytes intermedius Vier.
Plenoculus apicalis Williams.
Niteliopsis kansensis Williams.
Niteliopsis foxii Vier.

Nyssonidæ.

Gorytes gulielmi Vier.
papagorum Vier.
subaustralis Vier.
Nysson clarconis Vier.
intermedius Vier.

Philanthidæ.

Philanthus clarconis Vier.
magdalenae Vier.
Dideneis crassicornis Vier.

Pemphredonidæ.

Passalœcus equalis Vier.
Diodontus brunneicornis Vier.

Crabronidæ.

Trypoxylon quintilis Vier.
regularis Vier.
Crabro canonicola Vier.
cinctibellus Vier.
clarconis Vier.
Crabro papagorum Vier.
Oxybelus exclamans Vier.
viciniformis Vier.
Notoglossa calligaster Vier.
pænemarginatus Vier.
tænigaster Vier.

Eumenidæ.

Eumenes bolliformis Vier.
enigmatus Vier.
cruciferarum Vier.
globulosiformis Vier.
marginilineatus Vier.
Odynerus yumus Vier.
amphichrous Vier.
anormiformis Vier.
cochisensis Vier.
congressus Vier.
delodontus Vier.
egregius Vier.

Order HYMENOPTERA.

Eumenidæ—continued.

Odynerus excentralis Vier.
gulielmi Vier.
leionotus Vier.
pimorum Vier.
microstictus Vier.
maricoporum Vier.
papagorum Vier.
pænevagus Vier.
percampanulatus Vier.
rectangulis Vier.
sulfuritinctus Vier.
pulverulenta Vier.
spectabiliformis Vier.
hidalgiformis Vier.
subtoltecus Vier.
canaliculatus Vier.
provisoreus Vier.
tempiferus Vier.

Vespidæ.

Polistes exclamans Vier.

Apoidea.

Andrena alaskensis Vier.
delosa Vier.
Perdita klagesi Vier.
Melissodes duplocincta Ckll.
galvestonensis Ckll.
herrickii Ckll.
hexacantha Ckll.
nigrosignata Ckll.
pallidisignata Ckll.
prælauta Ckll.
portivagans Ckll.
semitristis Ckll.
tenuitarsis Ckll.
Xenoglossa pruinosa, var. limitaris Ckll.
strenua, var. Kanensis Ckll.
Anthophora montaniformis Vier.
Synhalonia gilletti, sub. sp. snowii Ckll.
fuscotincta Ckll.
lippiæ, var. sublippiæ Ckll.
Diadasia afflicta perafflicta Ckll.
Exomalopsis snowii Ckll.
Psithyrus tricolor Franklin.
consultis Franklin.

Order DIPTERA. (African.)

Tabinidæ.

Hinea flavipes Adams.
Tabanus tarsalis Adams.

Asilidæ.

Promachus flavibarbis Adams.
apicalis Adams.
solus Adams.
negligens Adams.
Sisyrnodites major Adams.
nigrifimbriis Adams.

Order DIPTERA. (African.)

Bombyliidæ.

Systropus snowi Adams.

Syrphidæ.

Melanostoma bituberculata Adams.
Eristalis longicornis Adams.
aequalis Adams.
communis Adams.
dissimilis Adams.

Conopidæ.

Conops fumipennis Adams.
bellus Adams.
semifumosus Adams.

Muscidæ.

Paracompsomyia houghi Adams.
splendida Adams.
verticalis Adams.

Sciomyzidæ.

Sepedon ornatifrons Adams.
scapularis Adams.

Diopsidæ.

Diopsis affinis Adams.
nitidus Adams.
pollinosus Adams.

CONTENTS OF MUSEUM.

	Number of species varieties in regular named collections.	Number of specimens in regular named collections.
North American Coleoptera	8,089	35,052
" " Lepidoptera	3,756	12,208
" " Diptera	2,244	6,741
" " Hymenoptera	1,304	3,912
" " Hemiptera	1,064	3,724
" " Orthoptera	492	1,845
" " Neuroptera	293	....
Exotic Coleoptera	2,600	8,450
" Lepidoptera	981	1,716
Collections for studies in geographic distribution, variations and economic problems	......	182,000
Grand totals	20,803	255,640
Grand total in Museum	———	276,451

SUMMARY OF TYPES IN SNOW ENTOMOLOGICAL COLLECTIONS.

Neuroptera	1
Orthoptera	15
Hemiptera	45
Coleoptera	12
Diptera	490
Lepidoptera	100
Hymenoptera	258
African Diptera	25
Total	946

What the University, Through its Department of Entomology, is Doing for the State.*

1. *For the State in General.*
2. *For Each One of the 105 Counties in Particular.*

FOR THE STATE.

1. Extended investigations in alfalfa culture and insect life, with special reference to native grasshoppers.

2. Increased alfalfa yield one-third by methods of culture devised by th. department and now uniformly used over the entire state.

3. Demonstrated that bees largely increase the alfalfa seed yield.

4. Four thousand copies of manual, fully illustrated, on bee culture and management, distributed free over the state.

5. Fifteen thousand copies of directions for dealing with injurious grasshoppers, distributed over the state.

6. Eight thousand fully illustrated bulletins on alfalfa culture distributed over the state.

7. Eight thousand nine hundred and thirty-two boxes of green-bug parasites distributed over the state, a check to the inroads of this most destructive wheat insect.

8. Fifteen thousand bulletins, fully illustrated, on the green bug and how to control it by proper culture and use of parasites. Assisted by Professor Glenn and advanced students.

9. Ten thousand bulletins, fully illustrated, on insects most injurious to fruit trees, with Professor Headlee of the Agricultural College.

10. Two thousand circulars of detailed information dealing with special current problems.

11. Detailed survey of orchards, 1,142,466 trees, in seven counties, and the directions given owners for their management.

12. Investigations looking toward control of woolly aphis and crown gall, two of the most serious menaces to the nursery business.

13. Eradication of San José scale from seven counties.

14. Directed, in the past two years, 1910-'12, work of spraying 162,585 fruit trees.

15. Annual examination of nursery stock, making possible its sale and shipment.

16. Inspection of all imports of nursery stock from foreign countries. In this there has been detected and destroyed about 5000 brown-tail moths, an insect which is costing some of the eastern states in remedial measures thousands of dollars annually.

17. Survey each spring of wheat areas to detect presence of green bug. This at the request of the millers and grain men.

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* At the close of each biennium the Department is called upon for this information, and it has accordingly been deemed advisable to place this data here in permanent form for future reference. Since 1907 the activities of the Department along economic lines, in accordance with the assignment of the Kansas State Entomological Commission, has been confined to the southern half of the state.

18. Furnishing high schools with mounted collections without cost.

19. Detailed survey of insect life of thirty-five counties. Distinguishing the beneficial from the injurious. Assisted by Mr. F. X. Williams and advanced students.

20. In past fifteen years, performed entomological work of practical value in 105 counties.

21. State entomologist, entomologist to Kansas State Board of Agriculture. Entomologist to Kansas State Board of Horticulture, honorary member of Western Association of Nurserymen.

22. Addresses before various state societies on problems of economic value.

23. Answer from 5000 to 8000 letters annually to citizens of the state, giving information sought by them.

24. Federal act of August 20, 1912, requires all importations of trees, plants, shrubs, bulbs, etc., to be inspected at point of destination by properly authorized state authority. This department performs this service for the south half of the state.

25. Extended investigation on probable cause of the human disease pellagra.

26. Chairman of University research commission on the horse plague. The results of this work were to locate the cause in improperly cured forage, and to demonstrate conclusively that a change to properly cured forage eliminated the disease. At the time when the University undertook this work there were many theories advocated regarding the cause, and now practically all investigators engaged on the problem agree with the University's diagnosis.

27. Construction of federal legislation in interest of horticulture, and assistance in passage of same. For some ten years the federal authorities and horticultural interests had been unable to agree on federal legislation to protect this country against importations of foreign pests. There is now a federal statute, and Kansas has proper protection thereby. Two trips were made to Washington and frequent conferences held with the members of House Committee on Agriculture in connection with this work.

28. The large problems which concern the state from time to time, such as the native grasshoppers, chinch bugs, Hessian fly, green bug, and codling moth, as the preceding pages show from year to year during the past forty years as occasion required, have been the subject of special investigations by the department.

For example, in the year 1913 the department coöperated with county commissioners in the distribution of 170 tons of the dry poison for the extermination of grasshoppers.

FOR THE STATE, ARRANGED BY COUNTIES.

Allen County.

Eradicated infestation of San José scale.

Made examination and certified to the healthy condition of about $5000 worth of nursery stock during one year.

Distributed green-bug parasite.

Anderson County.

Directed the treatment of insects injurious to forest trees.

Distributed green-bug parasite.

Inspected nursery stock.

Conducted experimental work on chinch bug.

Atchison County.

Distributed green-bug parasites.

Made examination of the orchards with reference to a serious outbreak of apple blight. and reported same to the United States Department of Agriculture.

Barber County.

Made examination and certified to the healthy condition of about $5000 worth of nursery stock each year.

Distributed green-bug parasites.

Barton County.

Made annual examination and certified to the healthy condition of about $15,000 worth of nursery stock during the last eight years.

Established and maintained a distributing station for the distribution of the green-bug parasite.

Made a detailed survey of the insect life of the county.

Gave individual assistance to farmers in fighting grasshoppers.

Bourbon County.

Made annual examination and certified to the healthy condition of about $75,000 worth of nursery stock at four points during each of the last ten years, making possible its sale and shipment.

Distributed green-bug parasites.

Investigations of the sand fly with reference to its connection with the distribution of pellagra.

Brown County.

Made examination of orchards with reference to serious outbreak of apple blight, and reported same to the United States Department of Agriculture.

Distribution of green-bug parasites.

Butler County.

Distribution of green-bug parasites.

Chase County.

Distribution of green-bug parasites.

Chautauqua County.

Distribution of green-bug parasites.

Cherokee County.

Made annual examination and certified to the healthy condition of about $5000 worth of nursery stock during each of the last two years.

Distribution of green-bug parasites.

Cheyenne County.

Made a detailed study of insect life, with special reference to the species injurious and beneficial to agriculture, requiring the time of four men for one year.

Clark County.

Made a detailed survey of the insect life, with special reference to the species injurious and beneficial to agriculture.

Distribution of green-bug parasites.

Clay County.

Distribution of green-bug parasites. Special green-bug investigation conducted here.

Cloud County.

Made examination of orchards, with reference to a serious outbreak of apple blight, and reported same to United States Department of Agriculture.

Distribution of green-bug parasites.

Coffey County.

Made annual examination and certified to the healthy condition of about $30,000 worth of nursery stock during each of the last ten years, enabling the owner to offer same for sale and shipment.

Inspection of orchards and shade trees.

Distribution of green-bug parasites.

Comanche County.

Distribution of green-bug parasites.

Cowley County.

Made annual examinations and certified to the healthy condition of about $400,000 worth of nursery stock during each of the last sixteen years.

Distribution of green-bug parasites.

Crawford County.

Made annual examination and certified to the healthy condition of about $40,000 worth of nursery stock at three points during each of the last eight years, making possible its sale and shipment.

Distribution of green-bug parasites.

Survey of orchard and forest trees and advising owners as to methods of treatment.

Decatur County.

Made demonstrations of the value of the disc harrow in alfalfa culture, increasing thereby the alfalfa yield one-third.

Made detailed survey of insect life, with special reference to species injurious and beneficial to agriculture.

Distribution of green-bug parasites.

Dickinson County.

Made annual examination and certified to the healthy condition of about $10,000 worth of nursery stock during each of the last eight years.

Distribution of green-bug parasites.

Doniphan County.

Made examination of the orchards with reference to a serious outbreak of apple blight, and reported same to the United States Department of Agriculture.

Distribution of green-bug parasites.

Douglas County.

Made annual examination and certified to the healthy condition of about $300,000 worth of nursery stock at five different points, during each of the last sixteen years.

Eradicated a serious infestation of San José scale.

Detected of foreign importations seven nests, amounting to about 1500 of the brown-tail moth.

Erected an inexpensive plant for the manufacture of orchard sprays, demonstrating to farmers their independence of any spray manufacturing concern.

Took immediate charge of the spraying and management of one orchard and directed the work in two other large orchards.

Demonstrated in experimental orchard the efficacy of sprays in producing sound fruit and in increasing yield and market value of orchards.

Edwards County.

Established and maintained for many years experiment station for the exclusive study of alfalfa culture and insect life, with special reference to grasshoppers.

Developed and established on a firm basis the cultural value of the disc harrow in the production of alfalfa.

Demonstrated that disking and cross-harrowing in the spring increased the alfalfa yield about one-third.

Made annual examination and certified to the healthy condition of about $5000 worth of nursery stock during each of the last seven years.

The department here profited by the coöperation of Professor Dean, of the Agricultural College, in campaign against the grasshopper.

Elk County.

Distribution of green-bug parasites.

Ellis County.

Distribution of green-bug parasites.

Made detailed survey of insect life of the county, with special reference to species injurious and beneficial to agriculture.

Ellsworth County.

Distribution of green-bug parasites.

Finney County.

Conducted experiments with reference to the part played by bees in the production of alfalfa seed.

It was shown that bees increased the alfalfa seed yield fully two-thirds.

It was further shown that alfalfa was the best honey-producing plant in the state.

Survey of orchard and forest trees and direction of means of taking proper care of them.

Survey of the insect life of the county with special reference to the species injurious and beneficial to agriculture.

Distribution of green-bug parasites.

Coöperated with county commissioners in campaign against grasshoppers. Distributed poison—4000 pounds Paris green and 40 tons bran.

Ford County.

An extended demonstration through three seasons proved the value of the disc harrow in the production of alfalfa.

A detailed survey of the shade and fruit trees of Dodge City, and the direction of the necessary spraying of the trees infested with San José scale.

Annual examination, without cost to the state, at the State Forestry Station.

Survey of the insect life of the county.

Coöperated with county commissioners in campaign against grasshoppers. Distributed 4500 pounds Paris green, 45 tons bran. The department profited here by the coöperation of Professor Dean, of the Agricultural College, the Santa Fe and the U. S. Department of Agriculture.

Franklin County.

Made annual examination and certified to the healthy condition of about $350,000 worth of nursery stock during each of the last sixteen years, enabling owners to offer same for sale and shipment.

Prepared 4500 gallons of spray for one orchardist.

Examined some fifteen shipments of foreign importations of nursery stock, detecting thereon and destroying twenty-seven nests of the brown-tail moth, amounting in all to 5000 insects so highly destructive to forest and fruit and shade trees.

Fumigated about $40,000 worth of nursery stock.

Made detailed survey of fruit and shade trees and advised concerning methods of caring for them.

Investigations of sand-fly distribution with reference to its connection with the dissemination of pellagra.

Geary County.

Distribution of green-bug parasites.

Gove County.

Made a detailed study of insect life with special reference to the species beneficial and injurious to agriculture, requiring the entire time of four men during the entire season.

Graham County.

The extended demonstration through three seasons proved the value of the disc harrow in the production of alfalfa.

Distribution of green-bug parasites.

Study of the insect life with special reference to species beneficial and injurious to agriculture.

Grant County.

Made a detailed study of insect life with special reference to species beneficial and injurious to agriculture.

Gray County.

Distribution of green-bug parasites.

Coöperated with county commissioners in campaign against grasshopper Distributed poison—1700 pounds Paris green, 17 tons bran.

Greeley County.

Made a detailed study of insect life with special reference to species injurious and beneficial to agriculture, requiring the entire time of four men during a part of the year and of two men the entire season.

Greenwood County.

Made annual examination and certified to the healthy condition of about $25,000 worth of nursery stock during each of the last six years.

Distribution of green-bug parasites.

Hamilton County.

Maintained and established a station for five years, dealing with alfalfa culture and insect life, with special reference to native grasshoppers, increasing thereby the alfalfa yield one-third.

Demonstrated that bees were not only profitable for honey, but also for their part in increasing the alfalfa-seed yield fully two-thirds.

Gave individual assistance to the farmers in fighting grasshoppers.

Harper County.

Eradicated infestation of San José scale.

Distribution of green-bug parasites.

Harvey County.

Made annual examination and certified to the healthy condition of about $25,000 worth of nursery stock during each of the last sixteen years.

Corrected false report sent out by agent of Department of Agriculture on infestation of San José scale. This report, if allowed to stand, would have brought about great pecuniary loss to the nurserymen.

Distribution of green-bug parasites.

Haskell County.

Distribution of green-bug parasites.

Made detailed study of the insect life, with special reference to the species injurious and beneficial to agriculture.

Hodgeman County.

Distribution of green-bug parasites.

Coöperated with county commissioners in campaign against grasshoppers. Distributed poison—1000 pounds Paris green, 10 tons bran.

Jackson County.

Made annual examination and certified to the healthy condition of about $15,000 worth of nursery stock during each of the last twelve years.

Study of sand-fly distribution, with reference to its possible connection with the dissemination of pellagra.

Distribution of green-bug parasites.

Jefferson County.

Field laboratory for green-bug investigation.

Distribution of green-bug parasites.

Direction of work on orchard culture.

Jewell County.

Distribution of green-bug parasites.

Kept a man in the field directing work against the green bug.

Johnson County.

Owner of large young orchard at Lenexa asked the department to assume direction of its scientific management, and this the department did.

Distribution of green-bug parasites.

Kearny County.

Distribution of green-bug parasites.

Study of insect life, with special reference to species injurious and beneficial to agriculture.

Coöperated with county commissioners in campaign against grasshoppers. Distributed poison—2500 pounds Paris green, 25 tons bran.

Kingman County.

Distribution of green-bug parasites.

Inspection of nursery stock annually, making possible its sale and shipment.

Inspection of shade and fruit trees for San José scale.

Kiowa County.

Established and maintained a field station for the distribution of the green-bug parasite.

Labette County.

Eradicated San José scale, the most serious menace to horticulture in one portion of the county.

Made detailed examinations of shade and fruit trees at Parsons, and directed spraying with the purpose of eradicating this scale from the city.

Made annual examination and certified to the healthy condition of about $300,000 worth of nursery stock at three points during each of the last twelve years, making possible its sale and shipment.

Investigation of sand fly, with reference to its connection with the transmission of pellagra.

Lane County.

Made a detailed study of insect life, with special reference to species injurious and beneficial to agriculture, requiring the entire time of four men during the entire summer.

Distribution of green-bug parasites.

Gave individual assistance to the farmers in fighting grasshoppers.

Leavenworth County.

Made annual examination and certified to the healthy condition of about $40,000 worth of nursery stock during the last ten years.

Distribution of green-bug parasites.

Lincoln County.

Distribution of green-bug parasites.

Linn County.

Made annual examination and certified to the healthy condition of about $40,000 worth of nursery stock, making possible its sale and shipment.

Made annual examination and certified to the healthy condition of about $2000 worth of greenhouse stock, enabling owner to offer same for sale and shipment.

Distribution of green-bug parasites.

Inspected orchards and advised owners as to methods of culture and management.

Logan County.

Made a detailed study of the insect life with special reference to species injurious and beneficial to agriculture.

Distribution of green-bug parasites.

Lyon County.

Made annual examination and certified to the healthy condition of about $10,000 worth of nursery stock during the last six years.

Distribution of green-bug parasites.

Marion County.

Made annual examination and certified to the healthy condition of about $10,000 worth of nursery stock during each of the last sixteen years.

Established and maintained an experiment station on green bug and other insects damaging the wheat.

Marshall County.

Made examinations of orchards with reference to a serious outbreak of apple blight and reported same to the United States Department of Agriculture.

Distribution of green-bug parasites.

McPherson County.

Made annual examination and certified to the healthy condition of about $5000 worth of nursery stock during each of the last four years.

Distribution of green-bug parasites.

Meade County.

Distribution of green-bug parasites.

Study of the distribution of sand fly in its connection with the possible transmission of pellagra.

Study of insect life with special reference to species injurious and beneficial to agriculture.

Coöperated with county commissioners in campaign against grasshoppers. Distributed poison—1500 pounds Paris green, 30,000 pounds bran.

Miami County.

Distribution of green-bug parasites.

Mitchell County.

Kept a man in the field directing work against the green bug.

Montgomery County.

Made annual examination and certified to the healthy condition of about $10,000 worth of nursery stock at two points during each of the last ten years.

Study of the sand fly with its possible connection with the transmission of pellagra.

Survey of orchards and shade trees, giving advice as to methods of culture and management.

Distribution of green-bug parasites.

Morris County.

Made annual examination and certified to the healthy condition of about $40,000 worth of nursery stock during the last eight years.

Directed the spraying of a 125-acre orchard during three years.

Distribution of green-bug parasites.

Morton County.

Made special study of insect life with special reference to species injurious and beneficial to agriculture.

Nemaha County.

Made examination of orchards with reference to serious outbreak of apple blight, and reported same to United States Department of Agriculture.

Made annual examination and certified to healthy condition of about $6000 worth of nursery stock during each of the last twelve years.

Distribution of green-bug parasites.

Neosho County.

Made annual examination and certified to healthy condition of about $50,000 worth of nursery stock during each of the last twelve years, enabling the owner to make sale and shipment.

Distribution of green-bug parasites.

Survey of shade trees and fruit trees and direction of methods for control of tent caterpillar pest.

Ness County.

Investigation of horse plague in western Kansas.

Study of insect life with special reference to species injurious and beneficial to agriculture.

Distribution of green-bug parasites.

Gave individual assistance to the farmers in fighting grasshoppers.

Norton County.

The extended demonstration through three seasons proved the value of the disc harrow in the production of alfalfa.

Distribution of green-bug parasites.

Study of the insect life with special reference to species injurious and beneficial to agriculture.

Osage County.

Distribution of green-bug parasites.

Osborne County.

Distribution of green-bug parasites.

Study of insect life with special reference to species injurious and beneficial to agriculture.

Ottawa County.

Distribution of green-bug parasites.

Pawnee County.

A detailed survey in the city of Larned of shade and fruit trees, and directing the spraying of the area.

Distribution of green-bug parasites.

Phillips County.

Kept a man in the field directing work against green bug.

Pottawatomie County.

Distribution of green-bug parasites.

Pratt County.

Eradicated infestation of San José scale.

Made examination of and certified to healthy condition of about $5000 worth of nursery stock.

Distribution of green-bug parasites.

Study of insect life with special reference to species injurious and beneficial to agriculture.

Gave individual assistance to the farmers in fighting grasshoppers.

Rawlins County.

Made a detailed study of insect life with special reference to species beneficial and injurious to agriculture.

Distribution of green-bug parasites.

Republic County.

Distribution of green-bug parasites.

Made examination of orchards with reference to serious outbreak of apple blight, and reported same to the United States Department of Agriculture.

Reno County.

Made detailed examination of the orchards.

Directed spraying of infested orchards until, as far as our observation goes, the San José scale has been eradicated from that county.

Made annual examination and certified to the healthy condition of about $10,000 worth of nursery stock during the last six years.

Distribution of green-bug parasites.

Rice County.

Distribution of green-bug parasites.

Riley County.

Distribution of green-bug parasites.

Rooks County.

Distribution of green-bug parasites.

Study of insect life with special reference to species beneficial and injurious to agriculture.

Rush County.

Made a detailed survey of insect life with special reference to species beneficial and injurious to agriculture.

Distribution of green-bug parasites.

Russell County.

Distribution of green-bug parasites.

Saline County.

Distribution of green-bug parasites.

Scott County.

Study of insect life, with special reference to species injurious and beneficial to agriculture.

Distribution of green-bug parasites.

Coöperated with county commissioners in campaign against grasshoppers. Distributed poison—1000 pounds arsenic, 10 tons bran.

Sedgwick County.

A detailed examination of ten townships, giving specific directions to owners in each case on the best methods of orchard management, amounting in all to 305,082 fruit trees. Out of this number 52,032 were sprayed.

Made annual examination and certified to the healthy condition of about $45,000 worth of nursery stock during each of the last ten years.

Examined four large greenhouse plants during the last six years, making possible the sale and shipment of their goods.

Fumigated annually about $10,000 worth of stock during the last six years.

Distribution of green-bug parasites.

Seward County.

Study of insect life, with special reference to species injurious and beneficial to agriculture.

Shawnee County.

Eradicated infestation of San José scale.

Made annual examination and certified to the healthy condition of about $500,000 worth of nursery stock at seven different points during each of the last sixteen years.

Fumigated about $30,000 worth of nursery stock, enabling owners to ship same into states requiring such treatment.

Examined a large number of importations of foreign nursery stock, and destroyed thereon about 6000 brown-tail moths.

Distribution of green-bug parasites.

Sheridan County.

Study of insect life, with special reference to species beneficial and injurious to agriculture.

Distribution of green-bug parasites.

Sherman County.

Study of insect life, with special reference to species beneficial and injurious to agriculture.

Smith County.

Study of insect life, with special reference to species beneficial and injurious to agriculture.

Distribution of green-bug parasites.

Stafford County.

Established and maintained a distributing station for the distribution of green-bug parasites.

Gave individual assistance to the farmers in fighting grasshoppers.

Stanton County.

Study of the insect life, with special reference to species beneficial and injurious to agriculture.

Stevens County.

Study of insect life, with special reference to species beneficial and injurious to agriculture.

Distribution of green-bug parasites.

Sumner County.

Made annual examination and certified to the healthy condition of about $150,000 worth of nursery stock at four different points during each of the last fourteen years.

Distribution of green-bug parasites.

Thomas County.

Made a detailed study of insect life, with special reference to species injurious and beneficial to agriculture, requiring the entire time of four men during the entire season.

Distribution of green-bug parasites.

Trego County.

Study of insect life, with special reference to species beneficial and injurious to agriculture.

Distribution of green-bug parasites.

Wabaunsee County.

Distribution of green-bug parasites.

Wallace County.

Made a detailed study of insect life, with special reference to species beneficial and injurious to agriculture.

Washington County.

Made examination of orchards with reference to a serious outbreak of apple blight, and reported same to the United States Department of Agriculture.

Distribution of green-bug parasites.

Wichita County.

Made a detailed study of insect life, with special reference to species injurious and beneficial to agriculture, requiring the time of four men during the entire season.

Distribution of green-bug parasites.

Gave individual assistance to the farmers in fighting grasshoppers.

Wilson County.

Distribution of green-bug parasites.

Examination of fruit and shade trees and direction of methods for care and management.

Woodson County.

Distribution of green-bug parasites.

Wyandotte County.

Made annual examination and certified to the healthy condition of about $125,000 worth of nursery stock during each of the last sixteen years, making possible its sale and shipment.

Fumigated about $75,000 worth of nursery stock in order that same might be sold.

Made detailed examination of the conditions of all orchards, 125 in number, amounting to 129,422 fruit trees, in Shawnee township, giving explicit directions to the owners in each case on profitable management.

Held two public spraying demonstrations in larger orchards, which were attended by over 300 horticulturists, some coming from other counties. At these demonstrations the fruit-growers were shown how to make and apply the various sprays.

Distributed over 1000 bulletins on orchard spraying.

Directed the work of spraying 35,000 fruit trees.

Distribution of green-bug parasites.

Total number of counties........................ 105
Total number of items.......................... 240

Some of the Graduates of the University

who took their major work in the department of entomology.

Adams, C. F., Director and Entomologist of Arkansas Agricultural and Mechanical College, Fayetteville, Ark.

Aldrich, J. M., Entomologist, U. S. Department Agriculture.

Andrews, **Orrel** M., Science Illustrator, Illinois State University, Urbana, Ill.

Burrows, M. T., Professor Department Pathology, Medical School, Cornell University, Ithaca, N. Y.

Claassen, P. W., Assistant State Entomologist on Kansas Entomological Commission, Southern Division.

Crumb, **Ebb.** S., Member Staff of U. S. Entomologist.

Emery, W. T., Investigator for State Board of Health.

Glenn, P. A., Chief Inspector, Office of State Entomologist, Urbana, Ill.

Hungerford, H. B., Assistant Professor in Entomology, Kansas University.

Hunter, S. J., Head of Department of Entomology, University of Kansas. State Entomologist, Southern Division.

Hosford, **Ruby**, Assistant in Laboratory and State Work, University of Kansas.

Isely, **Dwight**, Holder Schuyler Fellowship in Entomology at Cornell University, Ithaca, N. Y. 1913-'14.

Kellogg, V. L., Professor of Entomology and Binomics, Leland Stanford University.

McDaniel, **Eugenia**, Instructor in Entomology, Michigan Agricultural College.

Meek, W. J., Associate Professor of Physiology, Wisconsin University.

Palmer, **Miriam**, Instructor in Entomology, Colorado Agricultural College, Fort Collins.

Parrott, P. J., Entomologist New York Experiment Station, Geneva, N.Y.

Sanborn, C. E., Head of Department of Entomology, Oklahoma Agricultural and Mechanical College, Stillwater, Okla.

Scheffer, T. H., Member Staff of United States Biological Survey.

Spangler, A. J., Chief Inspector, Minnesota State Nursery and Orchard Inspection Service, State Experiment Station, St. Anthony Park, Minn.

Weeks, **Ella**, Biological Artist, Kansas Agricultural College.

The above list does not include those graduates who took their majors in the department and are now practicing physicians and teachers of science in high schools.

Publications of Department of Entomology.

Adams, C. F.

1. 1903—Dipterological Contributions; K. U. Science Bul., vol. II, No. 2.
2. 1904—Notes on and Descriptions of North American Diptera; K. U. Science Bul., vol. II, No. 14.
3. ———Descriptions of Six New Species of Diptera of Kansas; K. U. Science Bul., vol. II, No. 5.
4. 1905—Diptera Africana, part I; K. U. Science Bul., vol. III, No. 6.

Aldrich, J. M.

5. 1892—A new Genus and Species of Tabanidæ; Psyche, pp. 236, 237; 1 fig.
6. ———A New Species of Phora; Canadian Entomologist, pp. 142-146.
7. ———The Systematic Position of the Diptera; Science, New York.
8. ———Revision of the Genera Dolichopus and Hygroceleuthus; K. U. Science Quarterly, pp. 1-26; 1 pl.
9. ———New Genera and Species of Psiloponæ; K. U. Science Quarterly, pp. 47-50.
10. ———The Dolichopodid Genus Liancalus Loew; Psyche, pp. 569-571.
11. 1894—New Genera and Species of Dolichopodidæ; K. U. Science Quarterly, pp. 151-157.
12. ———Courtship Among the Flies; Amer. Nat., pp. 35-37.
13. 1895—The Tipulid Genera Bittacomorpha and Pedicia; Psyche, pp. 200-202; 1 fig.
14. 1896—A Collection of Diptera from Indiana Caves; 21st Annual Report of the Geology and Natural Resources of Indiana; 1 fig.
15. ———The Dipterous Genera Tachytrachus and Macellocerus; Trans. Amer. Ent. Soc., pp. 81-84.
16. ———On the Diptera of St. Vincent (Dolichopodidæ and Phoridæ); Trans. Ent. Soc. Lond., pp. 309-345 and 435-439.
17. 1899—A Balloon-making Fly (published with L. A. Turley); Amer. Nat., pp. 809-812, with illustrations.
18. ———Goniops and other Synonyms; Ent. News, p. 351.
19. 1902—Dolichopodidæ of Grenada, W. I.; K. U. Sci. Bul., vol. I, No. 3.

Branch, Hazel E.

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Brown, Barnum.

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GAUMER, GEORGE F.

22. 1875—Observations on the Habits of Certain Larvæ; Trans. Kans. Acad. Sci., IV, pp. 22-24.

GLENN, P. A.

23. 1909—The Influence of Climate upon the Green Bug and its Parasites; Univ. of Kansas Bul., vol. IX, No. 2, pp. 165-200.

HOSFORD, RUBY C.

24. 1913—The Study on the Segmentation of the Head of Insects; pls. I-IV, this Journal.

HUNGERFORD, H. B.

25. 1912—Biological Notes on Some Kansas Hymenoptera; Ent. News, vol. XXIII, June, pp. 241-261; pls. 14, 15, 16 (with Williams).
26. ——Orchard Problems and How to Solve Them; Circular No. 3.
27. 1913—The Success of a Two-spray Calendar in a Kansas Orchard; Jour. Economic Ent., April, pp. 167-173.

HUNTER, S. J.

28. 1892—The Corn-root Worm, Diabrotica longicornis Say; Trans. Kan. Acad. Sci., XIII, pp. 131-133.
29. 1893—Insects Injurious to Drugs; Proc. Kans. Pharm. Assoc., pp. 99-102 (with L. E. Sayre); Amer. Jour. Pharm., July, 1893.
30. 1896—Notes on Injurious Insects; Trans. Kans. Acad. Sci., XV, pp. 50-53.
31. 1897—The More Destructive Grasshoppers of Kansas; Bul. Dept. of Entom., Oct., pp. 1-111, pls. I-IV (with F. H. Snow).
32. 1898—Scale Insects Injurious to Orchards; Bul. Dept. Entom., pp. 1-62, figs. 1-7.
33. ——On the Occurrence of Dissosteira longipennis Thomas; Psyche, VIII, pp. 291-292.
34. ——Dissosteira in Colorado; Psyche, VIII, p. 299.
35. ——Parasitic Influence on Melanoplus; K. U. Quart., VII, pp. 205-210, Oct., figs.
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39. ——The Coccidæ of Kansas, II; K. U. Quart., VIII, A, pp. 67-77, pls. XIII-XVII.
40. 1899—Fertilization of the Alfalfa Blossom by Bees; Quart. Report Kansas State Bd. Agric., March, pp. 219-223, 3 figs.
41. ——The Nurseryman and the Entomologist; 24th Proc. Amer. Assoc. Nurserymen, pp. 28-34.
42. ——The Commotion in Kansas and Missouri upon the Appearance of Dissosteira in Colorado; Psyche, VIII, pp. 384-386.

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44. 1900—Coccidæ of Kansas, III; K. U. Quart., vol. IX, No. 2, pp. 101-107, pls. XVIII-XXIV.
45. ———Alfalfa Culture and Insect Life; Quart. Rep. Kans. St. Bd. Agric., March, pp. 41-51, 5 pls., 3 figs.
46. ———Some Entomological Problems in Horticulture; Rep. Colo. St. Bd. Hort., vol. XI (1899-1900), pp. 54-57, 66-69.
47. ———The Melanopli of Kansas, part I; Psyche, vol. IX, pp. 63-64, June, 1900 (with W. S. Sutton).
48. ———The Melanopli of Kansas, part II; Psyche, vol. IX, pp. 76-78, July, 1900 (with W. S. Sutton).
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50. ———Spraying; Rep. Kans. St. Hort. Soc., 1900, vol. XXV, pp. 55-57.
51. 1901—On the Production of Artificial Parthenogenesis in Arbacia by the Use of Sea Water Concentrated by Evaporation; Amer. Journal Physiology, vol. VI, pp. 178-180, Nov. 1901.
52. ———Coccidæ of Kansas, IV; K. U. Quart., vol. X, pp. 107-145, pl. VIII, July, 1901 (issued Jan. 1902).
53. ——— Selection, Natural and Artificial; Western Fruit Grower, Oct. 1901, pp. 12, 13.
54. 1902—Elementary Studies in Insect Life (a textbook); 369 pages, 261 illustrations, April, 1902.
55. 1903—The Coccidæ of Kansas (a text for students in taxonomy); 120 pages. 15 plates, August, 1903.
56. ———On the Condition Governing the Production of Artificial Parthenogenesis in Arbacia; Biol. Bul., vol. V, No. 3, Aug.
57. ———The Study of Animal Life; Its Place in the Public Schools; Education, vol. XXIV, pp. 209-218, Dec. 1903.
58. ———On the Morphology of Artificial Parthenogenesis in the Sea Urchin, Arbacia.
59. 1904—The Mean Proportional in the Problems of State Education; Education, vol. XXIV, pp. 485-495.
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61. 1908—Experiments with and Knowledge of the Green Bug to Date; Rep. of Kans. St. Bd. of Agric., vol. XXVII, No. 105, pp. 35-57, March, 1908.
62. ———Report of State Entomologist to Entomological Commission of Kansas; state report.
63. 1909—The Green Bug and Its Natural Enemies; Bul. Univ. Kans., vol. IX, No. 2, 220 pages, 11 plates, 65 text figures.
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67. ———Report of the State Entomologist to Entomological Commission of Kansas; state report.
68. ———Report of the Entomologist of the Kansas State Horticultural Society; report of the State Board of Horticulture.
69. 1911—Report of the Entomologist of the Kansas State Board of Horticulture.
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73. 1913 Pellagra and the Sand Fly, II; Jr. Ec. Ent., Feb., pp. 96-101.
74. ———Apparatus for Maintenance of Thermal Climatic Conditions; Jour. Ec. Ent., April, pp. 196, 197.
75. ———Pellagra and the Sand Fly; report of National Association for the Study of Pellagra.
76. ———Department of Entomology, Historical Account, this Journal.

ISELY, DWIGHT.

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79. 1892—Notes on the Elementary Comparative Anatomy of Insects; pp. 1-12.
80. ———Kansas Notes; Insect Life, V, pp. 114-116.
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82. ———Notes on the Elementary Comparative External Anatomy of Insects; Trans. Kans. Acad. Sci., XIII, p. 111.
83. ———Insect Notes; Trans. Kans. Acad. Sci., XIII, pp. 112-115.
84. ———Common Injurious Insects of Kansas; pp. 1-117, figs. 1-61.
85. ———Two Grain Insects; Bul. Dept. Entom., Univ. of Kansas, pp. 1-10, pl. (with F. H. Snow).
86. ———Insects Injurious to Drugs; Proc. 13th Ann. Meet. Kans. Pharm. Assoc., pp. 105-110 (with L. E. Sayre).
87. ———Notes on Melitera dentata Grote; K. U. Quart. No. 1, pp. 39-41.
88. 1893—The Sclerites of the Head of Danais archippus Lab., K. U. Quart., II, No. 2, pp. 51-57, 1 pl.
89. ———The Horn Fly of Cattle; Bul. Dept. Entom., Univ. of Kansas, pages 1-7 (with F. H. Snow).
90. ———The Destruction of Insects by Fungi; Trans. St. Hort. Soc. of Calif. for 1893, pp. 29-32.
91. 1894—The Taxonomic Value of the Scales of the Lepidoptera; K. U. Quart., II, pp. 45-89, 17 figs., 2 pls.

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92. 1894—Insects Injurying Drugs; Proc. Kans. Pharm. Assoc. for 1894, pp. 69-70 (with L. E. Sayre).

93. ———An European Experiment with Insect Diseases; Third Ann. Rep. Kans. Univ. Exper. Sta., pp. 227-339.

94. ———Insects Injuring Drugs at the University of Kansas; Insect Life, VII, pp. 31-32.

95. ———Notes on the Elementary Comparative External Anatomy of Insects; pp. 1-20.

96. 1903—Two New Genera of Mallophaga; Biol. Bul. of Marine Biol. Lab., vol. 5, No. 2.

LOHRENZ, H. W.

97. 1911—The Woolly Aphis, Schizoneura lanigera; Jour. Ec. Ent., vol. IV, April, pp. 162-172.

MEEK, W. J.

98. 1903—On the Mouth Parts of the Hemiptera; K. U. Sci. Bul., vol. II, No. 9.

PALMER MIRIAM.

99. 1905—On the Dorsal Glands as Characters of Constant Specific Value in the Coccid Genus Parlatoria; K. U. Sci. Bul., vol. III, No. 5.

SANBORN, CHAS. EMERSON.

100. 1904—Kansas Aphididæ, with Catalogue of North American Aphididæ and Host-plant List; K. U. Sci. Bul., vol. III, No. L.

101. 1906—Kansas Aphididæ, with Catalogue of North American Aphididæ and Host-plant and Plant-host List, part II; K. U. Sci. Bul., vol. III, No. 8.

SCHEFFER, THEOPHILUS H.

102. 1895—Notes and Observations on the Twig Girdler, Oncideres cingulata Say; Insect Life, VII, pp. 345-347.

SNOW, FRANCIS H.

103. 1875—The Rocky Mountain Locust, Caloptenus spretus Uhler; Trans. Kans. Acad. Sci., IV, pp. 26-28.

104. ———The Larva and Chrysalis of the Sage Sphinx, Sphinx lugens Walker (eremitoides Streckerr); Trans. Kans. Acad. Sci., IV, pp. 28, 29.

105. ———Catalogue of the Lepidoptera of Eastern Kansas; Trans. Kans. Acad. Sci., IV, pp. 29-59 (503 species enumerated).

106. ———The Best Means of Defense against the Insect Enemies of the Horticulturist; Trans. Kans. State Hort. Soc., V, pp. 104-112.

107. 1876—List of Coleoptera Collected in Colorado in June, July and August by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci., V, pp. 16-20 (enumerates 304 species).

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SNOW, FRANCIS H.—*continued.*

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110. ———Hunting Amblychila; Amer. Nat., XI, pp. 731-735.

111. ———List of Lepidoptera Collected in Colorado in June, July and August by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci., VI, 70-75 (enumerates 104 species).

112. ———List of Coleoptera Collected Near Dome Rock, Platte Canyon, Colorado, by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci., VI, pp. 75, 76 (enumerates 94 species).

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114. ———List of Coleoptera Collected in Santa Fe Canyon, N. M., by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci. VII, pp. 70-73 (enumerates 237 species).

115. ———Douglas County Additions to the List of Kansas Coleoptera in 1879-'80; Trans. Kans. Acad. Sci., VII, pp. 78-79 (enumerates 144 species).

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118. ———Larva of Eurycreon rantalis Guen. (Web-worm); Psyche, III, p. 127.

119. 1881—List of Lepidoptera and Coleoptera Collected in New Mexico by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci., VIII, pp. 35-46 (315 species Lepidoptera, 53 sp. nov.; 514 Coleoptera, 17 sp. nov.).

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121. ———On Musca domestica versus Vespa occidentalis Cresson; Psyche, III, pp. 339.

122. ———A New Museum Pest, Trogoderma tarsale; Psyche, III, pp. 351, 352, June.

123. 1883—Three Noxious Insects—The Forest Handmaid Moth, the Maple Worm, and the Codling Moth; Second Quarterly Report Kans. St. Bd. Agric., pp. 93-101.

124. ———Homonivorous Habits of Lucilia macellaria, the Screw Worm; Psyche, IV, pp. 27-30.

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128. 1884—Preparatory Stages of Hyperchiria zephyria Grote; Trans. Kans. Acad. Sci., IX, pp. 61-62.
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138. ———On Experiments for the Artificial Dissemination of the Contagious Diseases Among Chinch Bugs; Trans. Kans. Acad. Sci., XIII, pp. 34-37.
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148. ———Two Grain Insects; Bul. Dept. Entom. Univ. of Kans., pp. 1-10, pl. (with V. L. Kellogg).

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SNOW, W. A.

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Segmentation of the Head of Insects.

Plates I to IV.

BY RUBY C. HOSFORD.

THE question of the segmentation of the head of insects has been much discussed, with the result that different observers have recognized from one to seven segments therein.

Savigny (1816) made a very important step toward the solution of the problem by suggesting that the movable appendages of the head were homodynamous with legs. Comparative anatomists, then, accepting this and seeing that each segment in the body of an insect has only one pair of appendages, have concluded that there are at least four segments in the head: *i. e.*, the antennal, the mandibular, the maxillary, and the second maxillary or labial. They also suggest that since the eyes in certain crustacea are borne on movable stalks, they may be the appendages of a fifth segment.

From this point the embryologist carries on the study. He has found that in the embryo there exist distinct segments, each corresponding to a pair of mouth parts. It has also been found that in some stages of development there are at least three pairs of distinct ganglia which go to make up the subœsophageal ganglion. Each of these pairs of ganglia corresponds to a pair of mouth parts.

Wheeler ('93) observed rudimentary intercalary or premandibular appendages, which others have homologized with the crustacean second antennæ. Folsom has found rudimen-

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tary chitinized intercalary appendages in adults of *Tomocerus, Orchesella,* and other Collembola.

Folsom in his study of the embryo of *Anurida* found seven pairs of primary ganglia, the extra one being the fifth, between those of the mandibular and maxillary segments. This is called the superlingual segment. According, then, to the conclusions set forth from the study of comparative anatomy and embryology, the insect head is composed of seven segments: the *antennal,* the *mandibular,* the *maxillary,* the *second maxillary* or *labial,* the *premandibular* or *intercalary,* the *ocular,* and the *superlingual.*

The order of arrangement of these segments may be determined by the position of the primitive ganglia that innervates them.

The supraœsophageal ganglion, or the brain, is composed of three pairs of primary ganglia: the protocerebrum innervates the compound eyes and the ocelli or the ocular segment; the deutocerebrum, the antennæ or antennal segment; and the tritocerebrum, the labrum or premandibular segment. The subœsophageal ganglion is composed of four pairs of primary ganglia: the first innervates the mandibles or mandibular segment; the second, the superlinguæ or superlingual segment; the third, the maxillæ or maxillary segment; and the fourth, the labium or second maxillary segment.

We have, then, the following order:

1.—Ocular.
2.—Antennal.
3.—Intercalary.
4.—Mandibular.
5.—Superlingual.
6.—Maxillary.
7.—Labial.

Having now decided that there are seven segments united to form the head capsule of insects, we wish to determine what sclerites belong to the different segments. Using the work of Comstock and Kochi as a working outline, I have endeavored by a series of comparisons to form for myself an opinion on at least some of the following points:

Areas of the external skeleton of the head; the structure of a typical segment; and the sclerites belonging to each head segment.

I. Areas of the External Skeleton of the Head.

By making a comparative study of the following insects: Orthoptera—cricket, cockroach, *Corydalis* (larva and adult), walking-stick, mantis, *Dahinia, Orchelimum, Decticinæ,* and grasshopper; and Coleoptera—*Amblychila,* I have made the following observations:

1. (*E. SU.*) *The Epicranial Suture,* though indistinct and small in *Dahinia, Orchelimum,* and *Decticinæ,* is present in all of the Orthoptera and can easily be traced in the *Amblychila.*

2. (*F.*) *The Front,* the first single sclerite between the arms of the inverted Y (*E. SU.*), is always present. It is enlarged by pushing up of *E. SU.*; smallest in larva of *Corydalis.* In the orthopterous forms it includes the paired ocelli and median ocellus when present. The beetle studied has no ocelli.

3. (*Cl.*) *The Clypeus,* the second of the single sclerites between *E. SU.* and the mouth, is sometimes separated from *F.* by a deep suture, and sometimes seems but a continuation of it, the suture being absent. The point of separation between the two is always to be determined by the invaginations of the anterior arms of the tentorium.

The clypeus is often divided by a transverse suture into *clypeus first* and *clypeus second.*

The clypeus is really composed of three parts in a transverse row, the part on the median line being *C. proper,* the lateral ones on the frontal margin being *Antecoxal pieces* of the mandibles. This division is shown especially well in the larva of the *Corydalis.* They can be located in the other specimens merely by their assumed position.

4. (*L.*) *The Labrum,* upper lip of the mouth, last single sclerite between *E. SU.* and the mouth, often appears as an appendage, but is really a portion of one of the head segments. In some cases the markings make it appear as composed of two parts.

5. (*E.*) The *Epicranium* in the forms studied includes the paired sclerites of the skull. These sclerites constitute the sides of the head and that part of the dorsal surface that is behind the arms of the epicranial suture (*E. SU.*).

6. (*V.*) *The Vertex,* the first pair of paired sclerites behind the arms of *E. SU.,* the dorsal portion of the epicranium; or that portion which is next the front and between the com-

pound eyes. In the heads of *Orchelimum, Decticinæ* and grasshopper these sclerites are much smaller than in the other specimens studied. The smaller the frontal sclerite the larger the vertex.

7. (*O.*) *The Occiput,* the part of the head behind the vertex and surrounding the occipital foramen. This is not always a distinct sclerite, but when it is, as in the *Corydalis,* it appears to be formed from the tergal portion of the united postgenæ. This is present in the grasshopper, *Corydalis* and *Amblychila.*

8. (*G.*) *The Genæ,* the lateral portions of the epicranium just back of and below the compound eyes.

9. (*P. G.*) *The Postgenæ.* Each genæ was divided by a more or less well-marked suture, and the part back of this forms the *postgenæ.* Comstock thinks that it is the upper part or continuation of these that forms the occiput. Packard thinks the postgenæ are distinct from the occiput, which he considers as a part of the labial segment. I favor Comstock's view, for, in the grasshopper especially, the occiput seems so evidently a continuation of the postgenæ.

10. (*Gu.*) *The Gula,* which is often absent, when present forms the ventral wall of the hind part of the head, and bears the labium or second maxillæ.

11. *The Cervical Sclerites,* the sclerites of the neck. Of these there are dorsal, ventral, and lateral ones.

There are two dorsal cervical sclerites in the neck of the cockroach. In *Amblychila* I distinguished none.

Melanoplus has two lateral cervical sclerites on each side. Between these is a prominent apodeme. I also found what appeared to be a smaller apodeme on each side. In *Amblychila* there are two small chitinized spots, one on each side, which are probably vestiges of the lateral cervical sclerites.

In the cockroach there are two ventral cervical sclerites; in the cricket there are five, arranged in two series; in *Stenopelmatus* there are three, arranged in two series; in *Corydalis* and *Amblychila* these sclerites are not found, but the gula is present.

Snodgrass thinks that these cervical sclerites do not belong to the head, but to thorax. He designates them as the *microthorax.*

12. (*OS.*) *The Ocular Sclerite.* "Each compound eye is situated in the axis of an annular sclerite which may be the basal segment of the ocular appendages." These annular sclerites are the ocular sclerites. They show especially well in the cricket and *Amblychila.*

13. (*AS.*) *The Antennal Sclerites,* annular sclerites at the base of each antenna.

14. (*Tr.*) *The Trochantin of the Mandible,* a distinct sclerite between the mandible and the genæ in some insects; indeed, in all that I studied.

II. The Structure of a Typical Segment.

Since the abdominal segments have lost their appendages, it is evident that a reduction of certain parts has taken place there, which makes it impossible to use them as typical segments. The thoracic segments are the more typical.

The parts of a thoracic segment as generally recognized are as follows: a ventral part, sternite; two lateral parts, pleurites; and a dorsal part, tergite. Each segment is composed of two subsegments. "The line separating the subsegments passes, on the pleural aspect, between the episternum and the epimeron; and, on the tergal aspect, between the scutum and scutellum"; on the sternal aspect, between the sternum and sternellum.

The line of union between the episternum and epimeron is the apodeme, which is an invagination of the body wall. The division on the sternal aspect of most insects is not easily recognized, but it shows plainly on the metathorax of *Stenopelmatus* and the nymph of *Pteronarcys.* As the apodemes show the division of the pleural subsegments, so the furca shows their division on the sternite.

Embryologists have also proven that each segment "is composed of a median and two lateral fields, and that the appendages are developed as evaginations of the lateral fields."

III. Sclerites Belonging to Each Head Segment.

1. Ocular or Protocerebral.

Tergal sclerites. No trace.

Sternal sclerites. Front. Contains ocelli which are innervated by protocerebrum. Decided ridge in *Mantis* front may indicate sternum and sternellum.

Pleural sclerites.—One-half of vertex and corresponding gena. These probably represent lateral elements of sternum, because they enclose the ocular sclerite, which represents the appendage of this segment.

Appendages. Ocular sclerite.

2. *Deutocerebral or Antennal.*

Tergal sclerites.—No trace.

Sternal sclerites.—Clypeus. Formed from portion of procephalon, the central swelling of the cephalic end of the body of embryo insects. It is not the first segment nor does it contain the mouth, which falls in the tritocerebral segment, but is between the front and the mouth; therefore, it is a sclerite of the second segment.

Pleural sclerites.—Antennal sclerites. Lateral elements of sternite, because the antennæ arise from them. Even when antennæ seem to be postoral the basal part of the rudiment of the antennal sclerite appears to abutt against the procephalon.

Appendages.—Antennæ.

3. *Tritocerebral or Second Antennal.*

Tergal sclerites.—No traces.

Sternal sclerites.—Labrum. Formed from procephalon; contains mouth, which is in third segment.

Pleural sclerites.—None determined.

Appendages.—Second antennæ, when found.

4. *Mandibular.*

Tergal sclerites.—Occiput. Continuation of the postgenæ which form the pleural sclerites. Packard considers this as belonging to the sixth or labial segment, but as far as my observations have gone I agree with Comstock. It seems to me to be a continuation of the postgenæ, which Packard also considers as belonging to the mandibular segment.

Sternal sclerites.—Pharyngeal sclerites. Found in the floor of the mouth cavity of *Melanoplus* on each side just behind the superlinguæ. They are back of the superlinguæ, which shows that they must precede superlingual sclerites in the course of the invagination of the mouth. They are also closely connected with the mandible. Since in this region sclerites are frequently developed secondarily, Comstock does not think

that much stress should be laid on this supposed homology. I, myself, do not think the evidence brought forward on this point is very conclusive.

Pleural sclerites.—Postgenæ. A suture which is the more or less open mouth of an apodeme divides the postgenæ as does the apodeme the pleurites of the thoracic segments. The mandibles, like the coxæ of the legs, fit into the openings where the apodemes begin.

The antecoxal pieces. In *Gryllus* and the larvæ of *Corydalis* the mandibles articulate with a sclerite distinct from the clypeus. This corresponds to the antecoxal piece in the thoracic segments.

Appendages.—Mandible and trochantin, a small sclerite at base of mandible in Orthoptera and *Amblychila.*

5. *Superlingual.*

Tergal sclerites.—None found.

Sternal sclerites.—Represented by that part of the floor of the mouth cavity which bears the superlinguæ.

Pleural sclerites.—Represented by that part of the floor of the mouth cavity which bears the superlinguæ.

Appendages.—Superlinguæ.

6. *Maxillary.*

Tergal sclerites.—None found.

Sternal sclerites.—Lingua. This is the unpaired portion of the hypopharynx, and evidently pertains to the sternite of this segment, because it arises between the rudiments of the maxillæ.

Pleural sclerites.—Maxillary pleurites. There is a narrow band or sclerite that runs around the posterior margin of the epicranium. This is the posterior pleurite. The anterior one is scarcely visible except in a few insects, as in the cockroach and cricket. Between these two sclerites is an apodeme, which forms the posterior arm of the tentorium. In *Amblychila* this apodeme and the two sclerites are very clearly seen.

Appendages.—Maxillæ.

7. *Labial or Second Maxillary.*

Tergal sclerites.—Probably dorsal cervical sclerites.

Sternal sclerites.—Ventral cervical sclerites and gula. The ventral sclerites are often arranged in two series, showing the subsegments, and divided into two or three in each segment, showing the lateral and median fields. In some insects, as adult of *Corydalis* and *Amblychila*, they have united to form the gula.

Pleural sclerites.—Lateral cervical sclerites. These sclerites are best shown in *Melanoplus*. These under high-power lenses showed one prominent apodeme and one smaller one. Comstock mentions but one apodeme, and thinks that it helps to prove that these are the epimeron and episternum of a segment. The posterior of these sclerites articulates with the episternum of the prothorax, and the anterior one with what we believe to be the epimeron of the maxillary segment. I do not know what the smaller apodeme signifies.

Appendages.—Second maxillæ or labium.

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Morphology and Biology of the Membracidæ of Kansas.*

BY HAZEL ELISABETH BRANCH, A. B.

(Submitted in partial fulfillment of the requirements for the degree of master of arts.)

Plates V to XXI.

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MEMBRACIDÆ:

1.—Morphology and Ecology of *Enchenopa sinuata* Fab.

2.—Taxonomy of Kansas Forms.

* This is one of a series of studies on Kansas Homoptera. The head of the department has assigned each of the different families to a graduate student. Some of these have already been published, others are to follow.

MEMBRACIDÆ.

(Order HEMIPTERA.- Suborder HOMOPTERA.)

The family Membracidæ, although entirely phytophagous in its habits, confines itself for the most part to weeds and grasses. It is not a large family, as it includes not more than 1500 described species, but it is of wide distribution.

Geographical Distribution.

Frogatt states that the Membracidæ is a group confined to the tropical regions and well represented in Australia, but better in South America, where the forms are large and more profuse. Notwithstanding this statement, this family is found all over the United States and Canada, Great Britain, Australia, New Zealand, Philippine Islands and New Guinea, Sumatra and Ceylon; in Brazil, Amazons and Ecuador; on temperate slopes of the Himalaya mountains, and on high ground in Central Africa. The distribution seems to follow the isothermal lines of temperature rather than the boundaries of the zones. However, a peculiar instance is noted in that Europe, excluding the British Isles, is void of the family, with the exception of three species of *Centropida.*

On account of its jumping habits, it is difficult to collect, and there are many localities, no doubt, where the form remains unobserved. Those forms in the tropics are more prolific than those in the temperate zones; are larger and of more brilliant colorings than the more northern species.

In the United States the following states have reported collections: Alabama, Arizona, Colorado, North Carolina, California, Florida, Georgia, Vermont, Missouri, Oregon, Virginia, New York, Texas, New Jersey, Wyoming, Illinois, and Kansas.

In Kansas the following counties have yielded specimens: Neosho, Reno, Douglas, Finney, Rawlins, Gove, Cheyenne, Cowley, Sedgwick, Woodson, Wilson, Allen, Seward, and Sheridan.

Description of Family.

The family Membracidæ, commonly called tree hoppers, belongs to the suborder Homoptera of the order Hemiptera, and is placed by Buckton between Cicadidæ and Cercopidæ. The classification as given by Comstock in "Introduction to Entomology" is as follows:

Beak evidently arising from the mentum; tarsi three jointed; antennæ minute, setiform; ocelli only two in number or wanting; males without musical organs; prothorax prolonged into a horn or point above the abdomen .... MEMBRACIDÆ.

The head is usually perpendicular, and when viewed from the front appears somewhat triangular, with large globular eyes protruding on either side. On the face or cephalic aspect of the head and between the compound eyes are situated the two small ocelli.

In all genera the prothorax is abnormal, being produced upward and backward or forward into numerous shapes. In the Kansas forms, at least, it extends well back over the abdomen, concealing the mesothorax and metathorax, and frequently continuing as far back as the tips of the tegmina. It rises from the head in a perpendicular line, and is as wide as the head, extending back of the compound eyes and under the mesothorax for a short distance, by means of small lateral arms. (See fig. 34, pl. X.) Frequently the prothoracic legs are removed with the prothorax, as they are connected to the lateral arms by a delicate membrane. Back of the compound eyes the prothoracic lateral margin rises and turns caudad suddenly under the suprahumerals, thus forming the lateral angles, or humeri. (See fig. 7, pl. VI.) Fastened into this angle is a tiny sclerite, which seems to help in the protection of the tegmina.

In the prothorax there are four main divisions, the metopidium, procephalon, dorsum, and posterior process, although there are no definite sutures to mark the divisions.

METOPIDIUM is the sloping portion of the front of the prothorax extending from the head to the front of the dorsum, and bearing the suprahumeral processes (fig. 5, *a*, pl. VI). It may extend in a horn over the head as in *Campylenchia curvata* (fig. 11, pl. VII), or it may be void of any protuberance on the top. The suprahumeral processes are the lateral protuberances seen at the sides over the compound eyes and humeri (fig. 5, *e*; fig. 7, *x*, pl. VI). These suprahumerals are variable in shape, and are sometimes so obscure as to appear absent until the hand lens is used. The procephalon is the portion above the metopidium. In the exotic forms it may extend backward as a horn and be branched into several spines, but among the Kansas species this form is not found. The procephalon is not present in our forms except in the two genera *Enchenopa* and *Campylenchia* (figs. 11, 12, pl. VII). The dorsum is the portion from the suprahumerals to the tail. It is convex in the Kansas forms and without any

processes, usually surmounted by a prominent longitudinal median carina.

Posterior process is the sharply constricted portion at the caudal extremity of the prothorax. It continues, frequently, to the tips of the tegmina, and usually ends in a sharp, black point. (Fig. 5, at *c*, pl. VI.)

The prothorax is almost always pitted and is sometimes pilose. It is highly developed and may take on various shapes and forms; in fact, the family has been likened to Brownies on account of the queer facial expression and the grotesque appearance of the prothorax. There are some forms with two "humps," one caudad, or back of the other, as in *Entylia sinuata* (fig. 61, pl. XVI), while other forms bear only one spine or "hump," as in *Enchenopa binotata* (fig. 13, pl. VII), and *Campylenchia curvata* (fig. 11, pl. VII).

In some cases this single protuberance may be over the head and be a formation of the metopidium, called the procephalon, as in the two foregoing species; or it may be a crest on the dorsum over the abdomen, as in *Telamona* (fig. 31, pl. VIII; fig. 73, pl. X). Frequently the pronotum rises high in front, and by sloping backward from the metopidium forms a high tectiform hood over the abdomen, sloping down posteriorly to the posterior process, as in *Archasia* (figs. 22, 23, pl. IX) and *Stictocephala* (fig. 17, pl. VII; fig. 29, pl. IX).

In all the above-mentioned forms the suprahumerals are obtuse and minute, but in *Ceresa* the prothorax bears a prominent lateral horn on either side just back of the head (figs. 5, 6, 9, 10, pl. VI). In a few cases the pronotum may not present any protuberance except obscure suprahumerals, and the metopidium may rise only sufficiently high to cover the thorax. It thus seems to form a close protection for the thorax and abdomen, as in *Micrutalis* and *Acutalis* (figs. 18, 19, 20, 21, pl. VIII) and *Vanduzea* (figs. 14, 15, pl. VIII). Among the genera, other than those found in Kansas, the pronotum may not cover the abdomen, and in some cases does not conceal the mesothorax and metathorax, but ends in elevated and protruded spines or balls of odd shapes.

TEGMINA. The tegmina are elongate or lanceolate, membranous throughout, transparent in the main, but sometimes coriaceous and smoky in regions. The tegmina are unequally divided into corium, or embolium, and clavus (see fig. 75, pl.

XIX), which are separated by a fold (indicated in the drawing by a dotted line). The *corium* is the anterior portion of the tegmen, and, according to Goding, has a costal and three longitudinal veins proceeding from the base. In no case in the Kansas forms does this hold good, there being no more than two longitudinal and the costa, and frequently only one longitudinal, and the costa, proceeding from the base of the corium. Goding names the veins as costa, radia, and two ulnar. In case of *Cyrtolobus vau* and *Campylenchia curvata*, this is consistent if the two ulnars are fused at the base, but in the majority of forms there is but one vein other than the costa proceeding from the base of the corium.

In the study of the nymphal pad some of this fusing and the disappearance of several veins is cleared up. In the nymphal pad there are two veins in the costal region, the costa and subcosta; these fuse in the adult and are usually referred to as the costa. (See fig. 75, pl. XIX.)

Frequently, as in *Ceresa bubalus*, the one longitudinal vein, other than the costa, is branched soon after leaving the base, and forms the radial and one ulnar vein. In the nymph pad is found one other vein "media," which is fused with the radia in the adult.

The *clavus* has usually two anal veins, one of which frequently forms the posterior margin of the tegmen for some distance; the other anal vein usually joins the marginal vein at about its middle point. Much more discussion of the veins in tegmina of different species could be given, but observations on the drawings of the tegmina will give a conception as to the variation of the venation.

Cells of the tegmen (and in this instance I take *Ceresa bubalus* as a typical illustration, as it appears to be nearly constant) have four basal cells, the third of which is frequently referred to as the sutural area, as it contains the sutural fold between the clavus and corium. (See fig. 75, pl. XIX.) The costal cell in all forms is long and slender, proceeding to the first apical cell without the intervention of a discoidal cell.

The cells between the apical cells and the basal cells are known as *discoidal cells*, and usually number three.

The apical cells are typically five in number, although some genera may have only four, as in *Micrutalis*. These cells are marginal and are surrounded by nervules, no nerves or nervules

extending to the outer edge of the tegmen in this region; but are surrounded by an unveined membrane, the limbus. (See fig. 75, pl. XIX.) The third apical cell is characteristic in genera, and often forms the basis for classification. The tegmina are not covered laterally by the pronotum, but are free, united to the thorax below the humeri of the pronotum. When at rest, the tegmina lie with the costal region downward, as in the Aphididæ.

THE WINGS are more or less spatulate and broad; smaller than the tegmina, the anterior margin being about equal to the posterior margin of the tegmina. When at rest the wings are folded once and lie between the tegmina and abdomen, the costal region downward.

The wing is uniformly transparent and clearly veined. Here is again found the division into the corium and clavus, the corium usually having the costa and two other longitudinal veins (radia and ulnar) proceeding from its base. Here the costa does not always form the anterior margin as in the tegmina, almost the entire nerve area being bounded by the narrow limbus.

In the clavus are two anal veins, the second of which frequently lies in the posterior margin. There are three and sometimes four basal cells, in the third of which is a sutural fold. There are no discoidal cells, and frequently only three apical cells, although there may be more in some genera.

THE HIND LEGS are fitted for jumping. The femora are cylindrical and curved, the tibiæ quadrangular, prismatic or spatulate. In the metathoracic leg the tibia is densely spined, with the points of the spines downward, toward the end of the claws. The tarsi are composed of three segments, the first one longer than the other two. The last segment of the tarsus ends in a pair of sharp, black claws. (Fig. 2, pl. V.)

COLOR. Buckton figures some of the species in brilliant reds, yellows, and vivid greens, but the Kansas forms are modest in their colorings. Some few are pale green when alive, as *Ceresa bubalus, Ceresa taurina, and Stictocephala,* turning tawny when dried. A great number are mottled brown and tan, with touches of black or white, sometimes both. (See *Entylia sinuata,* figs. 61, 62, pl. XVI; *Ceresa diceros,* fig. 6, pl. VI; *Vanduzea,* fig. 15, pl. VIII; and *Telamona,* fig. 73, pl. X.) The only bright colors met with in the Kansas species occur in

the ocelli, which in life are usually a cherry red, and frequently remain so when dried. *Enchenopa binotata* (fig. 13, pl. VII) has two yellow spots near the region of the median carina. Some species are polished black, and may be outlined with palish yellow, as *Micrutalis calva*, while others are a dull black with rouch surface. A few forms, *Micrutalis occidentalis*, for instance, are frequently orange with more or less dark marking toward the head. *Publilia modesta* is diamorphic, and during a season may produce forms almost white with a downy surface.

SIZE. According to Buckton the forms may be as large as two English inches (about 50 mm.) in wing expanse; but 20 mm. will include our largest species, *Ceresa bubalus* and *Talamona ampelopsides*, which are 9 to 10 mm. from tip of tegmina to front of head. Our smallest species, *Micrutalis occidentalis*, is not more than 3 mm. in length. The sizes vary greatly within the species, and the male is almost invariably smaller than the female.

LIFE HISTORY OF ENTYLIA SINUATA.

PLATE XVI.

As far as the writer has observed or can ascertain from reports, the genera of the Kansas forms of Membracidæ live on the leaves and twigs of shrubs, bushes, and weeds. No form has been found living in ants' nests, as the members of the subfamily Tragopidæ do, but numerous species of ants are found on the vegetation with the Membracidæ, supposedly attending to their wants and being repaid in honey dew exuded from the anus. At least three species of Formicidæ have been collected with Membracidæ, namely *Formica fusca*, and another of the same genus, but the species is not determined; the third is *Prenolepis imparis*.

Entylia sinuata are found in great numbers upon the under sides of the leaves of *Cnicus altissimus* Willd.

NOTES. Food plant, *Cnicus altissimus*. Place, a shady grove on the east slope of a hill. Temperature records were kept on a self-recording thermometer, and during the observations, from June 29 to July 23, the minimum was 72° F.; the maximum 91.9° F.

On June 29, 1909, a pair is noted. In the morning (June 30) the male is missing, but the female sits quietly on the

midrib on the underside of the leaf with her head pointed toward the apex of the leaf. In the evening of the same day the female is missing, and two dark longitudinal, parallel lines about 10 mm. in length are discernible on the midrib. With a hand lens (12 $\times$) the eggs can be made out. They are embedded in the midrib, but the ends of the eggs are visible, appearing clearly and of a white color. (See *a*, fig. 56, pl. XVI.)

There is no perceptible change until four days later (July 4), when the slits are found burst open and the sides of the eggs are exposed to view. (Fig. 56, pl. XVI, at *B*.)

On the ninth day of July the slit is spread further, and hatching is in progress. The egg is 7/8 mm. in length, and has a small protuberance at the "hatching end," which is the last end to leave the ovipositors and is that portion visible in the midrib after the egg has been deposited.

When first hatched the nymph is pale yellow, or nearly colorless, but after a period of thirty minutes the color and markings begin to appear. The head, first thoracic segment and tip of abdomen become dark brown, while dark markings are noticeable on the second, third, fourth and fifth rings of the abdomen. The other portion of the dorsal aspect of the body is pale green. The ventral portion of the thorax and abdomen is white, with legs of a pale, transparent yellow. Each of the abdominal segments, except the first, bares two dorsal and two lateral spines or tubercles, one on each side, tipped with black hairs. The second and third segments of the thorax (the undeveloped mesothorax and metathorax) bear hairs in place of spines. The mesothorax, though light in color, bears a dark spot on the front edge. On the cephalic or front edge of the head are four hairs, and there is a hair cephalad and one caudad of each compound eye. The nymph, when one hour old, measures 1 1/8 mm. and is extremely active.

The antennæ are pale and transparent, delicately haired, and are very nearly equal to the length of the antennæ on the adult forms, being about one-half the length of the nymph. (See fig. 58, pl. XVI.)

The prothoracic segment, which is dark brown, is a third wider than the mesothoracic segment and as wide as the head. This prothoracic enlargement is, no doubt, the beginning of the overdevelopment of the prothorax to be seen in the maturing

and adult forms. In this first instar, it is interesting to note that there is an articulation between this segment and the head. The head, which is dark and shiny, is extremely large in proportion to the body; in fact, it is larger in a line from back to front in dorsal aspect than in the adult forms. (Fig. 58, pl. XVI.)

The *mouth parts* are enlarged out of all normal proportion, the distal end of the beak reaching to the end of the sixth abdominal ring. (See fig. 57, pl. XVI.) The ocelli are found in about the normal position.

On the twelfth day (counting from the date of oviposition and on the third day of the life of the nymph), July 12, occurs the first moult. In this second instar the enlargement of the prothorax takes on a shape similar to that in the adult form, except that it does not extend back over the abdomen, but it does extend far enough to cover the mesothorax. The prothorax bears the shovel-like horn and the notch which forms the dorsal hump. The head is reduced in size in this instar. The second, third, fourth, fifth, sixth, seventh and ninth abdominal segments bear two dorsal hirsute spines, the lateral ones having disappeared. The third, fourth and fifth segments are marked with dark dorsally and about half way down the lateral face. The nymph, in the second instar, measures 2½ mm. in length.

A curious fact noticed is, that in the nymphal stages the forms do not exhibit any jumping power, but run very rapidly. When four days old the measurement is 3 mm., but they have not moulted.

On the fifth day after hatching (July 14) the second moult occurs. In this third instar a differentiation of color is observed. A number of the forms are dark with black "hoods," while others are light with tan hoods. Upon further observations, this color difference seems to be the indication of the sex to be formed in the adult stage, the dark ones emerging as males and the light ones as females. In this instar also the wing pads appear. (See fig. 59, pl. XVI.) When nine days old (July 18) the third moult occurs. In this fourth instar we have the stage which is comparable to the pupa stage in forms having complete metamorphosis. In figure 60, plate XVI, is seen the "pupa," with the prothoracic enlargement spilt open ready for the emergence of the adult. This emer-

gence occurred when the nymph was fourteen days old (July 23). The imago is transparent, of a pale greenish-gray tinge, void of markings. It is active and will jump immediately upon emerging. Some were observed kicking off the old shell or jumping away from it. Within twenty minutes or half an hour the color markings begin to appear, and in less than an hour the imago is not discernible from the individuals many days older.

SUMMARY.

Egg stage	9 days
Larva stage—First instar	3 days
Second instar	2 days
Third instar	4 days
Pupa or fourth instar	5 days
Total	23 days

Twenty-three days are necessarily consumed from time of the oviposition of the egg until the form reaches the adult stage. As nine days are used in the development of the embryo, we have two weeks as the time from hatching until the form emerges as an imago. Mrs. Rice, in her report on the life history of *Entylia sinuata,* states two weeks as the time from hatching to adult stage if ants are present, and one week if undisturbed by ants. In my experiments indoors, without the presence of ants, the forms seemed unable to moult successfully and died before reaching maturity. This fact leads me to believe that the ants are necessary factors in the life of an individual membracid.

From three to four days after emergence the female commences to lay eggs. It has not been absolutely ascertained, but has been more or less satisfactorily observed, that one female lays more than one egg during her life, each mass averaging about thirty-five eggs.

The number of eggs is also indefinite, but as forms have been observed late in May and nymphs found as late as the first of November, and as it takes approximately four weeks from the time an egg mass is laid until a female from that generation begins to deposit her eggs, the writer feels justified in estimating six or seven broods in a season.

As to the winter state, it is conjectured that it is spent either in the egg stage or as adult, protection being obained from the fallen leaves. On October 24 adult forms, a few nymphs in the pupa stage and newly emerged adults were observed, not-

withstanding the occurrence of two heavy frosts. On November 1 several nymphs and adults were found on a food-plant stalk which had been taken to the laboratory for search of egg masses. No evidence of the theory that the form passes the winter in the egg stage has been ascertainable up to this date.

MORPHOLOGY.

EXTERNAL ANATOMY.

Head.

The head of a membracid is arranged in two planes; one vertical and parallel with the transverse planes of the body of the insect, the other set at an angle of about 95 degrees, or little more than a right angle, to the vertical plane. (Fig. 38A, pl. XI.)

This vertical plane (which is continued by the cephalic face of the metopidium), when viewed in cephalic aspect, appears as an isosceles triangle. The suture between the head and the metopidium of the prothorax forms the base, and the globular eyes form the equal angles. The ventral edge of the face, which is formed by the clypeus, is the vertex of the triangle; the sides of the loræ extend from clypeus to compound eye, and form the sides of the triangle. (See fig. 62, pl. XVI.)

Before the head can be viewed in its entirety the prothorax must be removed, as the top of the head is concealed by the præscutum. The suture, although in an approximately straight line, slopes slightly downward toward the sides, thus giving the base of the metopidium a curved appearance. (See fig. 62, pl. XVI.) This suture is not articulate in the adult forms, and although easily opened, care must be taken in removing the prothorax, as there are tiny arms produced from the front of the lateral angles of prothorax, which surround the head back of the compound eyes. Frequently, if these arms are not first broken away, the head will pull off with the prothorax. These arms extend almost around the union of the head with the thorax, and reach to the coxæ of the prothoracic legs, to which the arms are attached by a delicate membrane. (Fig. 34, pl. X.) The prothorax removed, the head or cephalic aspect thereof can be viewed. This ventral plane is flat when viewed laterally, but is really curved slightly backward on the sides, the middle of the curve being the central line dividing the face into bilateral halves. In this aspect three divisions

of the head can be seen, namely: Epicranium, clypeus, and loræ. (Fig. 35, pl. XI.)

THE EPICRANIUM, in the generalized insect, is the dorsal part of the head lying back of an inverted Y-shaped suture (Comstock and Kochi). In this family the suture is clearly marked, the main suture branching at the top of the clypeus and the arms of the suture formed by the lateral edges of the clypeus. The top of the epicranium is almost flat, although there is a slight indentation at the suture and the line curves down slightly to meet the compound eyes. In dorsal view (fig. 1, pl. V) the epicranium narrows from front to back, rolling gently backward and then dropping suddenly to the occiput (fig. 40, pl. XII). The vertex of the epicranium is just back of the suture between the head and prothorax.

The compound eyes are considered the outgrowth of the epicranium, and are situated at the extreme lateral edges of the sclerite. They are large and globular and composed of thousands of hexagonal facets. As the ventral surface of the eye contains approximately as many facets and is as large in area as the cephalic surface, it would seem that the downward vision of the insect would equal its forward vision. (Fig. 35 at *c*, and 37A at *c*, pl. XI.)

Ocelli.—Situated in the front of the head, in an unsutured division of the epicranium, named the *Frons*, and nearer the clypeus than the vertex, lying either side of the epicranial suture, are the brilliant little ocelli. (Figs. 35 and 37A at *o*, pl. XI.)

LORÆ. Separated by no apparent suture, but nevertheless a division of the epicranium, are the loræ. Their lateral edges extend from the base of the compound eyes to the ventral point of the lateral edge of the clypeus. This division line is about midway of the lateral edge of the clypeus in an oblique line upward to the base of the compound eye. There is thus formed a small triangle with two long and one short side, the short side being next to the clypeus. (Fig. 35 at *l*, pl. XI.)

CLYPEUS.* This sclerite has been discussed and pointed out by the foregoing descriptions until it needs very little explanation. In this cephalic aspect it is triangular and with a curved base, the apex of the triangle at the epicranial suture.

* In the nomenclature of the mouth parts the author follows Muir & Kershaw (28) in that she considers what many systematists call frons, clypeus and labrum, respectively the clypeus, labrum and epipharynx.

The ventral edge is densely hirsute. The whole cephalic face is deeply pitted or punctate and frequently mottled with dark patches. (Fig. 35 at *y*, pl. XI.)

The plane at an angle of 95 degrees to this cephalic face is also a triangle, the base being the ventral edge of the cephalic face and the apex the distal end of the epipharynx. (See Fig. 37A, pl. XI.)

In this plane are found the mouth parts proper, and here are situated all the typical sclerites of a suctorial mouth, namely, clypeus, labrum, epipharynx, mandibular and maxillary sclerites with their respective setæ, and the labium or beak.

Situated also in this plane are the genæ or cheeks, and the antennal sockets with the delicate antennæ. The compound eyes are also visible in this plane. When at rest the beak lies between the coxæ of the legs of the insect and close to the sternum, but when in use it is lowered onto the food plant by special muscles.

THE GENÆ (fig. 37A at *g*, pl. XI) are irregular quadrangular plates surrounded by the compound eyes, the mandibular and maxillary sclerites and the overhanging loræ. These genæ, with the maxillary sclerites, form the lateral edges of this plane of the head.

ANTENNAL SOCKET. (Fig. 35 at *x*, pl. XI.) Situated on the inner edge of the genæ, and lying against the ventral face of the clypeus and under the overhanging edge of the loræ, is the circular socket or antennal sclerite, its edge next to the genæ being the quadrant of a circle.

ANTENNÆ. (Figs. 36 and 37A, pl. XI.) The antennæ are pale in color and extremely minute and bristle-like. So minute and delicate are they that they are scarcely discernible with a pocket lens; in fact, they are frequently absent in mounted specimens, as they are easily broken off.

The antenna, which measures 0.45 mm. in length, is composed of three segments—two stout basal segments (*m* and *n*, fig. 36, pl. XI), the second and heavier of which bears sensoria; the third segment is spur-like, having a thickened base and gradually becoming slender until the distal end is hair-like. This spur, although unsegmented, has more than fifty small divisions, the last one much longer than the others. (Fig. 36, *x*, pl. XI.) The antennæ are very deeply set into the socket,

there being found upon dissection an interior spine nearly as long as the two basal segments.

In caudal aspect the head presents a concave surface, smooth and unhaired or punctured. Only small margins of the compound eyes can be seen. (Fig. 40, pl. XII.)

Branching out from the occipital plates which surround the cavity are seen the tentoria (*t*, fig. 40, pl. XII); from these is a narrow chitinized bar with three pairs of branches—one pair inward to support the œsophagus and attached to the cephalic face, just above the suture for clypeus, the second pair toward the thorax to help join the head to the thorax, and the third pair join to meet the bar which supports the labium.

Mouth Parts.

In ventral aspect (fig. 37A, pl. XI) the clypeus appears as a fleshy, swollen cushion, very large in proportion to the other sclerites, and rising in a dome. It is haired and its lateral edges fit down tightly upon the other sclerites. (See fig. 37A at *y*, pl. XI.)

LABRUM. Lying against the distal edge of the clypeus is the labrum, light in color, and also fleshy and slightly elevated, but smooth and unhaired. It is elongated, with lateral edges curving inward distad. (See *lb*, fig. 37A, pl. XI.) In its under side the edges are seen to curve inward to support the epipharynx. The distal edge is pilose.

EPIPHARYNX. Arising beneath and extending beyond the labrum is the external portion of the epipharynx. It is pointed, and grooved on its inner surface, fitting closely over the opening in the first segment of the beak, and making, with the labium, an almost perfect tube (fig. 38B, pl. XII) for the setæ, which come together and enter the beak at this point. It extends exteriorly to the joint between the first and second segments. (Fig. 37A, pl. XI.) On its inner or under side the epipharynx is grooved and extends in a slender, thin plate to the hypopharynx, which will be discussed later. (Fig. 39, pl. XII.)

MANDIBULAR SCLERITES. (Fig. 37A at *m*, pl. XI.) Lying laterad of the clypeus is a slender, curved plate immovably sutured with the clypeus. Muir and Kershaw seem to consider this sclerite as a lateral projection of the clypeus. They figure a mandibular suture but no scelerite. I find this suture between the clypeus and the projected plate of

Muir and Kershaw easily opened and the two sclerites separated. In figure 42, pl. XII, can be seen this sclerite with the labrum removed. It has a delicate distal process, which is covered and protected by the labrum. The cross on figure 42 shows where the seta is joined to the sclerite on its inner surface. This sclerite is also sparsely covered with hairs. It can not be seen in caudal aspect until the maxillary sclerite has been removed. (Fig. 41, pl. XII.)

MAXILLARY SCLERITES. (Fig. 37A at *n*, pl. XI.) Situated laterad and below the mandibular sclerites are the maxillary sclerites. They too are curved, but on the front face are much narrower than mandibular sclerites. They form the lateral surface of the plane, however, and in caudal aspect are wide. (Fig. 40 at *x*, pl. XII.) Each sclerite bears two processes, one above the other, and both grooved on their outer edges to assist the setæ better on their way into the head. The processes are also concealed under the labrum. Figure 39, plate XII, shows the inner surface of the clypeus, mandibular sclerites, labrum, and epipharynx. Situated on the distal edge of the clypeus and at the base of the epipharynx is the heart-shaped *hypopharynx*. Its function seems to be to cover the setæ as they merge together and continue the tubular structure of the pharynx and enter the grooved trough of the epipharnyx.

LABIUM. (Fig. 37A, pl. XI; fig. 38B, pl. XII.) This is the beak in which lie the setæ. It is composed of three segments, the second of which in cephalic view appears longest, but in lateral aspect seems to be joined to the distal segment by a sort of socket joint, the dorsal edges of which are formed by this second segment and the distal segment set into this socket thus formed. (Fig. 38A, pl. XII.) The first segment of the beak, as it passes under the labrum, clypeus and maxillary sclerites, broadens until it seems to form the base of the caudal cavity of the head. This segment forms the floor of the mouth, and, although chitinized, it is flexible. It is supported down the middle by a chitinized rod (fig. 40 at *r*, pl. XII) coming from the bar and joining the tentorial sclerites. This rod extends the entire length of the beak, ending in the third segment. On dorsal side the labium is closed and flat, but on the ventral side its edges curve inward to form a groove or trough for the setæ. The first two segments of the beak are slightly

hirsute, but the distal one is furnished with heavy spines or sensorial hairs. The end of the beak is rounded and heavily chitinized, probably thus protected, as this portion rests upon the food-plant during feeding.

SETÆ. The setæ are four in number, one pair assigned to the mandibular processes and the other pair to the maxillary.

The inner pair of *maxillary setæ* are separated with difficulty, as they appear to be tightly grooved, forming a tube. The distal end of this pair extends beyond the other pair and projects out of the distal end of the beak. (Fig. 38B, pl. XII.) The distal ends of the maxillary setæ are smooth and hair-like, but curved slightly at the extreme tip. They lie between the other pair until the first segment of the head is reached, when they become caudad in position and separate from each other on either side of the pharynx, disappearing into the head cavity. The inner end of each seta is thickened and is joined to the inner surface of the top of the head by heavy muscles. From this muscle descends a muscle to the inner face of the maxillary sclerite. (Fig. 41, pl. XII.)

Mandibular Setæ.—These are heavier than the maxillary setæ, although not as long. The distal end is blunt and its outer edge or surface bears eight black teeth. (Fig. 37B, pl. XII.) The setæ lie laterad of and surround the maxillary setæ in their passage into the head, but on entering the head they lie cephalad. These mandibular setæ are thickened in the head and connected to the sclerites by a well articulating joint. (Figure 41 at *v*, pl. XII.) From this joint extends a heavy muscle, which branches into two as it nears the top of the head.

For further investigation, observations must be based on sections, both transverse and longitudinal. In making observations on sections to ascertain the structures of mouth parts, it seems to be advisable to begin at the distal end of the beak and carry our observations into the head, piece by piece.

The general shape of the beak or labium is transversely elliptical, the outline varying somewhat in the different segments. The back or dorsal side of the labium (the side which lies against the sternum) is protected and strengthened by a chitinized rod. (Fig. 40, pl. XII.) The labial wall on the ventral side comes almost together, and then curves inward, forming a groove in which the setæ lie.

In a section near the tip of the beak (fig. 46, pl. XIII) the groove is shallow and opens in front, allowing the setæ free and unhampered movement. In this section the maxillary setæ are found, as they are longer than the mandibular setæ, which do not always extend to the end of the beak; in fact, the maxillary setæ are frequently a full mm. longer than the beak. In this third segment the shape near the tip is circular. The supporting rod is not visible in the figure, but the dorsal wall is indentated slightly in the middle, and the rod probably plays in this indentation. The maxillary setæ here appear as one, but upon closer observation this structure appears to be made up of two sections tightly grooved on their inner surfaces. One seta is situated above the other throughout the entire line of the beak.

A section near the middle of the third segment is shown at figure 45, plate XIII. Here the shape is elongated dorso-ventrad. (Fig. 38A, pl. XI.) In this section we notice the presence of the mandibular setæ; they are crescent-shaped, folding around the maxillary setæ. As the sections proceed toward the head, the labium becomes more circular in shape until near the upper end of the second segment it seems to be almost a perfect circle. (Fig. 44, pl. XIII.) A clearer conception of the various parts may be seen in figure 43, plate XIII. The shape is elliptical laterad and the strengthening rod is very clearly present. The epipharynx completely closes the tube and protects the setæ. The mandibular setæ show an opening which has been noticeable in the other sections. The shape of the setæ is circular on its outer edge, but on the inner edge it is triangular. (See *c*, fig. 43, pl. XIII.) The ventral curve folds around the maxillary setæ. The maxillary setæ show the grooved structure on their inner edges.

By making observations on figure 38A, plate XI, the reader will ascertain that a cut made transversely on the beak will also cut transversely, or nearly so, across the mandibular and maxillary sclerites. Such a section is shown at figure 47, plate XIII. The setæ have become much larger than they were in the beak. The maxillary setæ have separated from each other (*x* and *d*, fig. 47, pl. XIII). The clypeus shows its various braces and pharyngeal muscles.

In a longitudinal section—that is, across the vertical plane—the cut will be parallel to the longitudinal line of the maxillary

and mandibular sclerites. Such a section is shown at figure 48, plate XIV.

MAXILLARY SETÆ. As the setæ enter the head they separate, going either side of the pharynx and extending to the top of the epicranium. The setæ widen as they approach this extremity. Each seta is fastened to the epicranial wall by a heavy muscle (*a*, fig. 48, pl. XIV), from which arises another muscle, which is attached to the upper side of the seta and forms the retractory muscle. Attached to the lower edge of the widened extremity of the seta is a pair of muscles, one of which is branched. This pair of muscles proceeds along the line of the seta and are attached to the inner surface of the maxillary sclerite at its distal end, thus forming the protractory muscles.

MANDIBULAR SETÆ. The mandibular setæ, in the head, lie laterad of the maxillary setæ. They do not extend as far into the head, as they are joined to the mandibular sclerite by an articulating joint. The seta is connected to the epicranial wall, however, by a very strong muscle, the retractor (*t*, fig. 48, pl. XIV). The protractor is shown at *n;* this muscle is branched at the end attached to the sclerite. This attachment is not visible in the figure. In this same section is shown a longi-section of the salivary ejaculator or pump of the suctorial apparatus. (See *c*, fig. 48, pl. XIV.) Connected to this pump are the ducts which supposedly lead to the salivary glands, although the glands have not been satisfactorily located by the writer.

THE PHARYNX may be seen in both the transverse and longitudinal sections, as it enters the head in such a manner that a cross section of it is obtained near the back of the head in a transverse section (fig. 47, pl. XIII) and turns downward, passing over the œsophagal ganglion, and is found again in longi-section.

GANGLIA. In longi-section and through the compound eyes near the top of the head (see fig. 49, pl. XIV) the subœsophagal and superœsophagal ganglion are shown, with the maxillary setæ on either side of the subganglion over which the pharynx passes. The superganglion, or upper brain, is extremely large in proportion to the head, and lies forward toward the front surface of the face or epicranium. Branching out on either side of this ganglion is a large optic nerve which leads to the compound eye. (See *o*, fig. 49, pl. XIV.)

An endeavor has been made to locate the nerves governing the mouth parts, but as yet without success.

CLYPEUS. In sections shown at figure 47, plate XIII, and figure 48, plate XIV, the heavy muscular tissues on the interior of the clypeus are seen. They are transverse and longitudinal muscles, which presumably regulate the muscular contraction and retraction of the upper part of the pharynx, and for this reason are called the *pharangeal muscles.*

Summary.

In a median lateral longitudinal section of the entire head and beak, a final and more comprehensive conception of the entire structure is presented. A careful study of this section, combined with the others just referred to, give the following results (fig. 50, pl. XV) :

THE PHARYNX enters the head in a plane at an angle of about 60 degrees with the vertical or cephalic face of the head. It passes over the subœsophagal ganglion, and, turning suddenly downward, passes under the superœsophagal ganglion (see *b*). The pharynx proceeds toward the ventral face of the head until near the base of the distal end of the clypeus (*z*), when it turns sharply downward in a line parallel to the ventral face of the clypeus. At this turn the upper wall of the pharynx is formed by the hypopharynx (*h*), which joins itself to the epipharynx (*g*), lying beneath the labrum (*l*). The upper wall of the pharynx is expanded and compressed by the heavy muscles in the clypeus and labrum (*t*, *u*, *n*). The maxillary setæ (*x*) lie either side of the pharynx, gradually approaching each other until they meet, one lying over the other, forming a complete tube to continue the alimentary canal to the end of the maxillary setæ.

PUMP. (Fig. 50, *p*, pl. XV.) Situated below the pharynx is a fleshy bundle of muscles with an opening into a short duct, wihch appears closed at the forward end. From this duct are two smaller ducts (*k* and *o*, fig. 50), one leading into the pharynx, and the other presumably leading from the salivary glands.

BEAK OR LABIUM. The floor of the mouth is formed by the extension of the first segment of the beak (*f*, fig. 50, pl. XV), and is supplied with muscles near the curve of the first segment. These muscles are presumably used in lowering and raising the beak. Each segment has three pairs of lateral

muscles, and there are numerous muscles running longitudinally, which are not shown at figure 50, but may be seen in cross sections in figures 46 and 45 at *m, m,* plate XIII.

Running along the exterior surface of the floor and down the dorsal side of the beak is the chitinous rod used as a brace.

THORAX. The head is fastened to the prothorax by two muscles (*m-m,* fig. 40, pl. XII). It is fastened to the mesothorax by a pair of lateral muscles. The union with the mesothorax is completely covered by the prothorax with its lateral arms, back of the compound eyes.

Shape.—The prothorax may be seen in figure 61, plate XVI. It is compressed and the metopidium rises into a compressed and greatly elevated procephalon, which in lateral view is "spade-shaped." The dorsum is deeply sinuated at about one-third the way toward the posterior end. This sinuation forms the back of the procephalon and also the front edge of the dorsal hump. The color of the prothorax is a dull tan and brown, varying in the sex. The color markings differ in some respects, but this is fully discussed under the head of *Entylia sinuata,* in the systematic paper at the close of this treatise. The mesothorax and metathorax are shown in dorsal aspect at figure 1, plate V. Here the bullæ, or lobes, are to be seen; also the articulation of the tegmina and wings with the body. In each section (meso or meta) the scutum or bullæ are elevated and polished; much enlarged in comparison with the other segments, as they contain muscles used in flying. The præscutum, scutum, scutellum and postscutellum are marked and indicated on figure 1.

Tegmina.

The tegmina of *Entylia sinuata,* like all of the genera of the tribe Polyglytini, are punctate and darkly coriaceous in the costal, radial and first basal cells. In *Entylia sinuata* the punctating is dense and heavy, as is shown in figure 1, plate V, and figure 83, plate XX.

The veins in the tegmen seem to be pushed anteriorly, leaving a wide, unveined area below the first ulnar vein. The second ulnar vein disappears soon after leaving the base, but reappears near the posterior margin, where it appears in a hook-shaped line curving into the anal vein of the clavus. (Fig. 64, pl. XVII.)

The discoidal cells are small and only two in number, unless the vacant unveined portion be considered a discoidal. The first three apical cells are small, the third one petiolate, while the third and fourth are abnormally large. There is one, and possibly two, anals proceeding out of the base of the clavus. The tegmen is 3.8 mm. from base and 1.2 mm. wide in broadest portion.

Wings.

The wing is typical of the family, having the three longitudinal veins—costa, radia and ulnar—in corium, and two in clavus. It is difficult at times to see the second anal vein. The limbus surround the veined portion except at the base and along the costal area. Wing measures 2.2 mm. from base to tip.

Legs.

The prothoracic, mesothoracic and metathoracic legs, in all genera, differ greatly. The prothoracic leg has a heavy coxa, which is joined to the arm of the prothorax by a heavy membrane. The prothoracic leg is almost as large as the mesothoracic. The tibia, however, appears heavier in the prothoracic leg, presumably because the prothoracic leg is more developed through the aid it gives during feeding time. The femur of the prothoracic leg, as well as that of the mesothoracic, is much curved, especially the outer margin. The tibiæ are slender and quadrangular, haired and spineless. The claws are longer than those in the metathoracic leg; are sharp, bearing a soft, spongy cushion between them. This cushion is perhaps used as a suction in clinging to the plant, as the insect shows strong clinging abilities and is not easily shaken off its plant. In the prothoracic leg the tibia is scarcely longer than the femur, but in mesothoracic it is one third longer.

The metathoracic leg, or "jumping leg," is the member with which the insect does its rapid work in locomotion. The femur is cylindrical, but is not as curved on the outer edge as the femur in the prothoracic or mesothoracic leg. It is narrower in the middle than on either end, having a more forceful lever power than in the other shape. The tibia is at least twice the length of the femur. It is quadrangular, with numerous black, shining spines on the four angular edges and also on the planes between. There are also dark spines around the distal end of the tibia and on the first joint of the tarsus. (See fig. 2,

pl. V.) The tibia and tarsi are densely haired, and the tibia is larger at its distal end than in any other portion of its length.

The Abdomen.

The abdomen is composed of the typical ten segments (eight and the two forming the genitalia). It is compressed and has a ridge on its medial dorsal area. Each of the eight segments bears a pair of dark markings either side of the ridge. The first segment is narrower than the metathorax, thus giving the insect a marked constriction just back of the wings. The body line curves outward, the fourth segment being some little wider than the first or eighth. Viewed laterally the spiracles can be seen. (See fig. 54, pl. XV.)

The *genitalia* form a part of the abdomen and must here be discussed.

THE MALE GENITAL ORGANS, viewed laterally, present all the typical sclerites. (Fig. 52, pl. XIV.)

The *supra-anal* plate (*g*, fig. 52, pl. XIV) is joined to the eighth abdominal segment by a heavy membrane. Proceeding from the ventral side of the lateral face of the supra-anal plate is a sclerite which extends caudad beyond this plate. Its ventral edge curves upward, forming an apex with the dorsal edge on the caudal extremity of the sclerite. It is densely haired and flexible. This sclerite is a *cercus*, and has a mate on the opposite side of the insect. (Fig. 52, *p*, pl. XIV.) These are used as claspers.

Clasper.—The most ventral plate in lateral aspect is a clasper. It is narrowed posteriorly, hirsute, and also has a mate. (See *r*, at figs. 52 and 51, pl. XIV.) Proceeding from the inner side of the claspers are four polished, claw-like appendages (two on a side). The posterior pair are larger than the other pair, which, on the other hand, are darker than the posterior pair (*x*, fig. 52, pl. XIV).

In ventral aspect the *subgenital* plate (see *g*, fig. 51, pl. XIV) is seen. It is a fleshy sclerite, dentate twice on its ventral edge. The two pairs of claw-like organs are attached to the cerci beneath this plate.

The *anal* plate, in lateral aspect, is boot-shaped, pale, and hirsute. It is joined to the supra-anal plate by a membrane. (See *y*, fig. 52, pl. XIV.)

The *copulatory organ* is little seen in lateral aspect, as it is situated on the ventral side of the anal plate, and is closely attached thereto. In ventral aspect this organ is seen lying against the anal plate (*k*, fig. 51, pl. XIV). It is highly chitinized and dark, bearing a set of conspicuous, polished elevations.

THE FEMALE GENITAL ORGANS. *Ovipositors.*—The last ventral segment is triangular in its caudal edge, the sides sloping obliquely from the middle. Proceeding from under this sclerite is a pair of long, slender, highly chitinized plates (*o*, fig. 53, pl. XV). Near the ventral plate of the abdomen these plates enlarge or broaden and surround the vaginal opening. These slender sclerites are pointed at the caudal extremity, situated close together, forming a groove for the placing of the eggs. These are the ovipositors.

Either side of the ovipositors is another long, slender sclerite. This with its mate form the *egg guides* (*r*, fig. 53, pl. XV).

In lateral aspect (fig. 54, pl. XV) are seen the supra-anal plate at *g*, the subgenital at *gs*. the cerci or claspers at *r*, and the egg guides at *e*. The ventral plate is shown at *v*. In the female the subgenital plate lies beneath the anterior edge of the ovipositors. On its posterior edge it is double curved (*g*, fig. 53, pl. XV).

Technique.

Three processes of killing were used. First, the hot-water method: Boiling water was poured over the specimens and allowed to stand without further heating, for five minutes. At the end of this time dehydration was commenced, using increasing grades of alcohol from 30 per cent to 70 per cent, and left in 70 per cent for keeping.

The second method: Gilson's solution—acetic alcohol with sublimate (see Lee's *Vade Mecum*)—was poured over specimens and allowed to stand from fifteen to thirty minutes. The solution was washed out with claret solution or iodine in 85 per cent alcohol. This washing must be repeated several times for an hour or two until no trace of the odor of acetic acid can be detected. If this acetic acid remains in the specimen it will cause the insect to swell, and there is danger of the abdomen bursting. The claret solution is replaced by 70 per cent alcohol for keeping.

The third method was to kill in picro-aceto-sublimate (see *Vade Mecum*).

The last two methods were found more efficient in external and coarse dissection, as the sutures were more distinct and the muscles less brittle than in the water-killing. Before much work could be done in external anatomy of the head, it was necessary to clear the heads by boiling for fifteen minutes in one part saturate solution potassium hydrate and ten parts water.

For sectioning, any one of the three fixative methods seemed equally good. On account of the difficulty through the chitin, the material had to be softened in sodium hypochlorite solution (saturate solution, one part to ten parts water, was found satisfactory). The writer left the specimens over night (about fourteen hours) in this solution, and then dehydrated up to 85 per cent alcohol, from which the specimens were put into cedar oil for twenty-four hours or longer.

For infiltration, watch glasses were partially filled with melted paraffin. The specimens, before being placed in the paraffin, were drained on blotting paper. This process makes the change of paraffin unnecessary. The infiltration continued for ninety-six hours.

Sections were cut ten microns, stained three to four hours in Mayer's carmulum, and mounted in Canada balsam.

TAXONOMY.

The following synoptical table of the subfamilies of the Membracidæ is taken from Van Duzee (41), who uses that given by Canon Fowler, who founded his work formally on that of Stal:

Scutellum wanting or entirely concealed by pronotum 1
Scutellum distinct and more or less uncovered, with its apex nearly always excavated or broadly sinuated and furnished on each side with acute angles .... CENTROTINÆ Stal.

1. Tarsi of equal length, or posterior pair longest 2
   Posterior tarsi much shorter than the anterior and intermediate .... HOPLOPHORINÆ Stal.
2. Tibiæ, at least the anterior and intermediate, dilated or foliaceous .... *II*—MEMBRACINÆ Stal.
   Tibiæ simple or very slightly dilated, never foliaceous 3
3. Third apical or terminal areole of the corium elongated, never petiolate .... DARNINÆ Stal.
   Third apical or terminal areole of the corium petiolate, the adjacent areoles contiguous before it 4

4. Elytra externally broadly coriaceous and opaque, with the veins of the coriaceous portion scarcely distinguishable, and the free margin broad ....TRAGOPINÆ Stal.
   Elytra entirely membranous, with the veins distinct or coriaceous and punctured at the base only.............*1*—SMILIINÆ Stal.

1.—SUBFAMILY SMILIINÆ* STAL.

The Smiliida are more northern in their contribution and form by far the greater portion of our North American fauna in this family.

Elytra free, with the clavus uncovered, its interior margin touching the external margin of the pronotum............*1*—CERASINI Godg.
Clavus and frequently a part of the corium covered by the pronotum.. 1
1. Wings with the terminal areole sessile, its base truncated.
2—TELAMONINI Godg.
   Wings with the terminal areole triangular, stylate................ 2
2. Base of the corium with two closely contiguous veins.
3—POLYGLYPTINI Godg.
   Base of the corium with three veins, usually contiguous.
4—SMILIINI Godg.

1.—Tribe CERASINI.

Corium with two veins contiguous at base, sometimes united in one.... 1
Corium with two distinct veins at base, contiguous at most, but for a short space at base, where they are subobsolete................ 2
1. Pronotum armed with suprahumeral horns, sometimes reduced to mere tubular angles ....1—*Ceresa* A. & S.
   Pronotum without suprahumeral horns, the sides of the metopidium, at most, obtusely angled.................2—*Stictocephala* Stal.
2. Elytra with five apical areoles, veins distinct....3—*Acutalis* Fairm.
   Elytra with four apical areoles, veins indistinct.
4—*Micrutalis* Fowler.

1.—Genus *Ceresa* A. & S.

In North America we find fifteen species, of which only three are recorded from Kansas. I give below a small key, based somewhat on that of Van Duzee (4):

A. Suprahumerals broad, stout and triangular.
   B. Elytra infuscated, metopidium pale, prothorax brown, transversely banded with pale near middle and a narrower pale marking near posterior process .... 2—*diceros* Say
AA. Suprahumerals acute, distinctly produced as horns, triangular, sometimes short. Elytra very transparent. Species green when alive, turning to tawny or green mottled with tawny when dried. Prothorax covered with small white dots.
   B. Metopidium slightly curved cephalad between the suprahumerals; produced at times into an obtuse angle; sometimes flat but never concave.
      C. Clypeus short at apex, continuing contour of cheeks, 1—*bubalus* Fabr.
   BB. Metopidium concave between the suprahumerals, sometimes flat or a trifle convex in the very middle. Suprahumerals (viewed from above) subterete, sloping upward and curving slightly backward.
      C. Clypeus produced at apex, forming an angle in contour of cheeks.
3- *tauriana* Fitch

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* To accord with the general custom of term endings in subfamily names, I have changed the ending from IDA to INÆ.

1.—*Ceresa bubalus* Fabr. Figs. 5, 7, 10, 87.

Green when alive, turning to a tawny or an ochreous hue when dried. Finely punctured with obscure whitish dots. Pronotum bearing laterally two large horns called suprahumerals, in front of the lateral angles. These suprahumeral processes point outward but never upward; are dark brown at the tips and along the upper margin as far as the union with the prothorax. The metopidium rises perpendicularly from the head, but slopes gently toward the sides, leaving an apparent carina down the middle of the face of the metopidium. The metopidium slopes backward as well as slightly upward, and, with the dorsal margins of the suprahumerals, forms an equilateral triangle, the apex of which is at the dorsal carina. Laterally, the suprahumerals slope inward and backward, forming the lateral edges of the prothorax. The prothorax is produced into a sharply constricted point at the posterior process. The prothorax extends nearly to the tip of the tegmina but does not cover them laterally. The sides of the pronotum slope inward and upward, meeting the dorsal carina and forming a high tectiform hood. From the apex of the plane of the metopidium, the dorsum slopes downward and backward until it meets the sharp, black point of the posterior process. The pronotum, caudad of the metopidium, possesses a strong median longitudinal precurrent carina, slightly piceous in spots. The lateral edges of the prothorax are strongly carinated. The clypeus is not produced beyond the face but the lateral edges continue the contour. Tegmina tawny but transparent. The base of the clavus slightly coriaceous. Tibiæ quadrangular.

Length, 8 to 10 mm. Described from thirty specimens.

HABITAT: Brownsville, Tex.; Buffalo, Colo.; Kansas City, Mo.; Manchester, Vt.; Douglas, Sedgwick, Finney, Graham and Rawlins counties, Kansas; Eastern United States, Southern Canada, and extending west to California.

2.—*Ceresa diceros* Say. Figs. 6, 88.

Prothorax brown, finely punctured and mottled or banded with light tawny spots, usually two on each side, one pair about the middle of the dorsum and the other pair near the posterior process. This process is black and polished. The general shape of this species agrees with that of *Ceresa bubalus*, but the suprahumerals are broader and thicker. The front margin of the metopidium is not produced into an obtuse angle, but the cephalic margin of the suprahumerals curves gently outward and backward until near the middle of the front margin, when the line abruptly protrudes forward, producing a slight bump. The metopidium is pilose and is tawny in color. Tips of suprahumerals black.

Length, 8 to 10 mm. Described from seventeen specimens.

Amyot and Serville described this species as *C. post fasciata*.

HABITAT: Colorado Springs, Colo.; Pennsylvania; New York; Nova Scotia; Kansas City, Mo.; Douglas county, Kansas.

3.—*Ceresa taurina* Fitch. Figs. 8, 9.

Green when alive, turning tawny when dry. Agreeing in many particulars with *Ceresa bubalus*, but the species is more slender and smaller. Suprahumerals more acute, curving upward and a little forward, making

the front margin of the metopidium present a concave line. Clypeus usually produced below the face, causing a break in the contour of the ventral line.

Length, 7 to 8 mm. Described from twelve specimens.

HABITAT: Oak Creek canyon, Arizona; Lush, Wyo.; Columbia and Kansas City, Mo.; Welland county, Ontario; Colorado; North Carolina; Douglas, Sedgwick and Rawlins counties, Kansas.

2.- Genus *Stictocephala* Stal.

This genus comprises a large number of species. Van Duzee gives eleven species for North America, three of which occur in Kansas. The members of this genus, like *Ceresa*, are green when alive, turning to a yellow or orange hue, frequently mottled, when dry, and covered over with small white dots. Its characteristic differentiation from *Ceresa* is th absence of the produced horn-like suprahumerals.

A. Carinate sides of the metopidium meeting before the middle of the body.
  - B. Metopidium, viewed from before, obviously widened upward to the rounded suprahumeral angles. Length of insect, 7.5 to 8 mm.
    - C. Lorae continuing the rounded contour of the cheeks; the clypeus scarcely longer than the cheeks. Last ventral segment of the female broadly and subangularly excavate behind. Inhabits a region east of the continental divide . . . . . 1—*inermis* Fabr.

AA. Carinate sides of the metopidium with no distinct meeting before the middle of the body.
  - B. Metopidium, viewed from before, widened upward to the obtuse suprahumeral angles.
    - C. Dorsum, viewed laterally, distinctly arcuate, metopidium high, its sides angulate or subangulate, distinctly carinate, uniting somewhat behind the middle of the dorsum. Face evenly and regularly punctate, carinæ frequently rufous. . . . . 3—*festina* Say.
  - BB. Metopidium regularly narrowing above the suprahumerals.
    - C. Carinate sides of the metopidium meeting at or near the middle. Dorsum elevated. Face smoothly corrugated, evenly and closely punctate. Clypeus and loræ little produced. Length of insect, 6 to 6.5 mm.
      - D. Pectus and outer face of femora black, clypeus briefly but obviously produced beyond the lines of the cheeks. 2—*lutea* Walk.

1.—*Stictocephala inermis* Fabr. Figs. 16, 17, 66 and 89.

This is the largest species of the genus. In cephalic aspect, the metopidium shows slight obtuse suprahumerals, but these are in no case produced as in *Ceresa*. The metopidium rises from the head in a perpendicular plane, which almost immediately inclines slightly forward, causing the front of the metopidium, when viewed laterally, to present a curved surface. The metopidium, above the line of the suprahumerals, curves gently backward. Cephalad of the middle of the pronotum, the plane of the metopidium is terminated by the union of the dorsal carinæ of the suprahumerals, thus forming an isosceles triangular plate as in *Ceresa*. From this point the dorsum slopes gently downward and backward to meet the posterior process, which is usually dark and always acute. The dorsum bears a longitudinal median carina, which is sometimes rufous or dotted with light brown. The sides of the pronctum are concave or inwardly arcuated, and the ventral line, which is carinated, slopes rapidly

to meet the constricted posterior process. The tegmina are slightly colored with dark coriaceous spots at the base. The pectus and outer face of femora black, but frequently light and concolorous.

Length, 7 to 9 mm. Described from twenty-five specimens.

HABITAT: Oak Creek canyon, Arizona; Trenton Falls, N. Y.; Kansas City, Mo.; Oregon (Canada mountains); Douglas and Cowley counties, Kansas.

2.—*Stictocephala lutea* Walk. Figs. 28, 29, 90.

This species, although commonly found and reported from Kansas, has not been collected by the writer. Therefore, this description is based on museum material only. It is somewhat smaller than *S. inermis,* but as the two species intergrade to a considerable degree, it is difficult to draw a fast and positive line between them. The specific differentiation of *lutea* from *inermis* lies in the convex metopidium (with its slightly and delicately carinated edges), which in *S. lutea* has its apex caudad of the middle of the pronotum. The dorsum is high and the sides well arcuated. The pectus and outer face of the femora are black.

Length, 7 to 7.5 mm. Described from twelve specimens.

HABITAT: Alabama; Mississippi; Arizona; Hayti; Sedgwick and Douglas counties, Kansas.

3.—*Stictocephala festina* Say.

The material at my disposal was accidentally injured, so that no detailed description can be given at this time.

3.—Genus *Acutalis* Fairmaire.

This genus is distinguished from *Micrutalis* by the fact that the *Acutalis* tegmina have five apical cells, while *Micrutalis* has but four. (See figs. 80, 81, 82.) There has been some question among investigators concerning the advisability of separating these two into different genera. The tegminal characters, however, would seem to be of generic value.

Van Duzee gives three species common to North America, but up to this time only one has been collected in Kansas.

Acutalis tartarea Say. Figs. 18, 19, 80.

Pronotum black and shiny. Metopidium rising perpendicularly for a short distance and then curving gently back over the abdomen. Small, inconspicuous suprahumerals, light in color. Lateral edges of pronotum light, extending to the posterior process, which is compressed into a point. Posterior process pale. Face black and shiny; compound eyes and ocelli light. Tegmina black with a purplish iridescence as far as the apical region, where the tegmina become transparent; nervules heavy. Metathoracic legs are heavily spined and of a greenish hue; other legs pale yellow, hirsute, and with a dark spot on the distal end of the tibiæ.

Length, 4 to 5.5 mm. Described from fifteen specimens.

HABITAT: Virginia and Douglas county, Kansas. Van Duzee gives the species as common throughout the Middle Atlantic States, and northward through New York to Canada.

4.—Genus *Micrutalis* Fowler.

This genus has only four apical cells in the tegmina. Frequently, as in *M. dorsalis* (a species, according to Van Duzee, not reported from Kansas), there is a fifth terminal areole; but this is not formed in the regular way, but by the crowding of this nervure against that forming the apex of the costal areole. In the Francis Huntington Snow collection at the University of Kansas the genus does not seem to be represented. It is there, however, but included in *Acutalis,* on account of the older manner of classification. The specimens labeled *Acutalis calva* and *Acutalis occidentalis* the writer classifies *Micrutalis,* on account of the four apical cells.

Van Duzee records six species from North America.

In the smaller and more typical species of this genus the terminal areole may be small, or even wanting.

Genus *Micrutalis* Fowler.

A. Size small; less than 4 mm., but more than 2.5 mm.
  - B. Pacific coast species, pronotum, when viewed dorsally, slightly rounded, at least not acute, on edges before posterior process.
    - C. Color pale, the dorsum sometimes marked with a brown median line, which may be expanded between the suprahumerals and before the apex . . . . 1—*occidentalis* Godg.
  - BB. Eastern species, with pronotum, viewed dorsally, with edges continuing the line directly with that of the posterior process. Pronotum relatively more acute than in the former.
    - C. Black marking much extended; the pronotum usually entirely black except at tip. In pale specimens the color of the dorsum is gathered anteriorly, and does not form a dorsal line widening before the apex . . . . 2—*calva* Say

1.—*Micrutalis occcidentalis* Goding. Fig. 81.

Although this species seems to be accredited to the Pacific coast, the F. H. S. collection records it from Brownsville, Tex. This fall (1911) the writer found one specimen in sweepings at Lawrence, Kan.

It is a small, pale species, in some cases almost void of color markings. In cases of this kind there is a slight collection of light brown color near the cephalic end of the pronotum. In other specimens this color may be dark and extend about midway to the tip of the pronotum.

Length, 2.8 to 3.2 mm. Described from seven specimens.

HABITAT: Brownsville, Tex.; Riverside, Cal.; Lawrence, Kan.

2.—*Micrutalis calva* Say. Figs. 20, 21, 82.

Prothorax smooth, black, and shiny. Posterior process, face and compound eyes pale. There are small, obscure, obtuse suprahumerals outlined with a pale yellow carina. Femora black. Tibiæ bear dark spots near femora. Tegmina clear, with pale but distinct neuration.

Length 3 to 3.5 mm. Described from ten specimens. Redescribed as *Smila flavipinnis* by Germar.

HABITAT (Van Duzee): Of wide distribution from southern New York to Florida, and west to the Rocky Mountains. F. H. S. collection records specimens collected in Texas, Missouri, and Kansas.

2.—Tribe Telamonini Godg.

A. Pronotum unarmed.
 B. Dorsum strongly compressed foliaceous................ 1—*Archasia* Stal
AA. Pronotum armed with a horn or dorsal crest more or less developed.
 B. Dorsum armed with a compressed horn, which is erect or nearly so, with a dorsal crest more or less elevated.
  C. Dorsal crest arising from behind the suprahumerals. If distinctly elevated, wider than high. Corium coriaceous, and if at all punctured only for a short space at the base.
   D. Dorsal crest rounded; obtusely pointed, truncate or sinuate at apex, sometimes scarcely elevated.......... 2—*Telamona* Fitch

1.—Genus *Archasia* Stal.

A genus whose species are green when alive, turning orcheous or tawny in museum specimens. Prothorax punctate and finely although obscurely dotted with white specks. Longitudinal median carina piceous in spots. Prothorax very highly elevated and compressed into a sharp helmet above the head.

Archasia galeata Fabricus. Figs. 22, 23.

This is the only species of this genus reported from Kansas. There are two species classified by Van Duzee, but the F. H. S. collection yields but one specimen of each of the two species, and *A. belfragi* is not reported from Kansas. On account of the scanty material, very little study could be made.

Contour of the prothorax entire, not having elevations or sinuations. Metopidium bears short, obtuse suprahumerals.

Habitat: Van Duzee reports the species from Colorado and Georgia, stating that it is less abundant than *A. belfragii* Stal in the Northern States, but is a prevailing form in the South. The specimen in the F. H. S. collection is from Douglas county, Kansas.

Length, 9.5 mm.

2.—Genus *Telamona* Fitch.

This genus contains the largest form found in Kansas, it measuring sometimes 11 mm. in length. The male is much smaller than the female and also darker in color.

A. Crest (viewed laterally) pyramidal, rather slender and narrowed upward.
 B. Crest narrowing above to a rounded point, posterior angle scarcely if at all indicated, its front sloping from the metopidium without a sinus at the anterior base ....1—*pyramidata* Uhl.
AA. Crest (viewed laterally) rectangular, broad, but little narrowed above.
 B. Crest nearly vertical before or sometimes overhanging. Gray or brownish species more or less distinctly banded or dotted with dark brown, sometimes almost black.
  C. Crest truncated above, the angles nearly or quite right angles.
2—*ampelopsides* Harris

1.—*Telamona pyramidata* Uhler. Figs. 30, 31, 84.

Color varying from a pale, tawny concolorous specimen through greenish ochre to brown with darker markings. In cephalic aspect the form is very broad and somewhat flat; the metopidium curves backward after rising perpendicularly for a short distance, and gently upward, forming a dorsal elevation back of the suprahumerals. This elevation or protuberance slopes abrubtly downward and then proceeds in an almost hori-

zontal line to the posterior process. The dorsal carina is prominent and piceous as far as the elevation, but caudad it becomes concolorous and obscure. There is frequently a dark color marking extending from back of the elevation to the lateral edge of the prothorax, slanting slightly caudad. End of prothorax diffused with dark. Tegmina transparent, except for the dark tip and slight coriation of base. Cephalic portion of the prothorax pale. Suprahumerals sometimes dark at the tips.

HABITAT: Colorado Springs, Colo.; Cheyenne, Douglas and Gove counties, Kansas; Missouri.

Length, 10.2 to 8.5 mm. Described from twenty-five specimens.

2.—*Telamona ampelopsides* Harris. Figs. 73, 74.

Redescribed as *Thelia cyrtops* by Fairmaire.

Color dark dusty brown, some specimens having a greenish cast in the lighter portions. Metopidium rising similar to that in *T. pyramidata*, but instead of sloping gently backward it rises abruptly to form the high rectangular dorsal elevation. The dorsal contour of this protuberance runs backward in an almost horizontal yet slightly descending plane until past the middle of the prothorax, when it slopes suddenly downward and then extends caudad, forming a lanceolate posterior process. Color, dark brown, the cephalic face of the suprahumerals bearing a splotch which extends toward but does not attain the median carina. This median carina is piceous. The cephalic edge of the elevation has color markings which extend downward and backward to meet the splotch at the caudal edge of the elevation on the side of the prothorax. This color may or may not extend as far as the posterior process, which is dark. Median carina is dark and prominent for its entire length. Femora dark on dorsal side. Tegmina smoky and darker at tip; clear in costal region. The males in this species are much darker than the females, being at times almost black, but with the markings visible.

Length, 11 mm. to 8.8 mm. Described from forty specimens.

HABITAT: Menand, N. Y.; Kansas City, Mo.; Manchester, Vt.; Douglas county, Kansas.

3.—Tribe POLYGLYPTINI Goding.

A. Pronotum usually not produced anteriorly; if at all, only very slightly.
- B. Dorsum regularly rounded transversely, punctate; prothorax not elevated in rugæ. The furcation forming the base of the terminal areole is a straight line or nearly so .... 1—*Vanduzea* Goding
- BB. Dorsum more or less elevated; the surface with longitudinal rugæ, which may become more or less reticulated; the furcation forming the base of the terminal areole forming an angle.
  - C. Dorsum strongly elevated, compressed, with a deep sinus whose base is rounded .... 2—*Entylia* Germ.
  - CC. Dorsum but slightly elevated; a little sinuated before the middle, the base of the sinuation being flat or angled, not regularly rounded. 3—*Publilia* Stal

1.—Genus *Vanduzea* Goding.

This genus may be distinguished by the absence of wrinkes or rugæ on the prothorax and by the peculiar shape of the terminal areole or third apical cell, which has a straight vein for a base instead of the

usual angle toward the base of the tegmen. The metopidium is not produced any higher than is absolutely necessary to cover the mesothorax and metathorax.

In the species common to Kansas the dorsum is transversely rounded and punctate. Van Duzee states that some species of this genus have the dorsum carinated and sinuated.

The color of the species of the genus *Vanduzea* is mottled with dark, either dark brown or black, with whitish or light oblique vittæ. The prothorax is pilose, the legs dark brown to black, with light hairs. The tegmina, except in the costal region, is transparent, the nervules with black or brown dotted lines. The tip of the limbus is infuscated.

Vanduzea arquata Goding. Figs. 14, 15, 68, 69, 78.

Color reddish brown, verging to black. There are white or light yellow markings or vittæ, an oblique spot joining the lateral margin, and a line just before the posterior process. Sometimes there is a small white spot on the dorsum almost concurrent with the spots on the sides. The pronotum bears no procephalon or crest and is smoothly rounded transversely. The metopidium rises slightly from the head and then curves gently backward to the dorsum, which is slightly arcuated to the posterior process. The metopidium (in cephalic view) is broad, with short, obtuse suprahumerals. Head and body and legs dark and pilose.

Length 5.1 to 4.5 mm.

HABITAT: Galveston and Brownsville, Tex.; Douglas and Congress Junction, Ariz.; Kansas City, Mo.; Kansas City, Kan.; Morton, Clark, Douglas, Stevens, Seward and Haskell counties, Kansas.

According to the determination in F. H. S. collection, there are two species common to Kansas, *V. arquata* and *V. vestita*. Van Duzee separates these species by the costal region of the tegmina. *V. arquata* has the costal cell coriaceous and punctured for nearly its whole length; *V. vestita* has the costal areole or cell concolorous, sparsely punctate near the base. If this classification be true—and I have every reason to consider it such—then there is but one species in the F. H. S. collection, as all the specimens agree with *V. arquata*. In Van Duzee's description of *V. arquata* he states that the suprahumerals are more prominent than in *V. arquata*. With this description as a basis, the specimens here can not be *V. vestita*, as there is no ascertainable difference in the prominence of the suprahumerals.

Genus *Entylia* Germ.

This genus has received a considerable list of synonyms, which I append at the close of the description of species. It is widely distributed east of the Rocky Mountains, and some species occur in considerable numbers, the writer having found extensive colonies in Kansas and Vermont.

The metopidium of the prothorax rises in a high elevation to form a distinct procephalon, almost perpendicular or sloping slightly forward on its cephalic edge. This procephalon is greatly compressed and extends rectilinearly caudad for a short distance, descending suddenly and abruptly into a deep sinus smoothly curved at the base. This sinus

forms also the front of a second elevation, or the dorsal hump, which does not rise as high as the procephalon, but is equally compressed, slopes down rapidly, making the dorsal hump, in lateral aspect, appear somewhat rectangular. After dropping for a distance about equal to the depth of the curved sinus, the dorsal line proceeds gently backward and downward to meet the blunt posterior process.

Entylia sinuata Fabr. Figs. 61, 62, 64, 83.

In looking over the individuals of this genus in F. H. S. collection, I find two species, or rather one species and a variety, *Entylia sinuata* and *Entylia sinuata* var. *bactriana*. Upon closer examination the writer finds that those determined as *E. bactriana* are all males, and those determined as *E. sinuata* are all females. In the life-history observations (recorded in this paper) the writer found the males agreeing with *bactriana* and the females agreeing with *sinuata*. F. C. Crawford, associate curator, division of insects, United States National Museum, states that there are both males and females of both species and variety in the collection there. From this information, and the study of life history, it may be inferred that there has been an error in the determination of the material in the F. H. S. collection. Whether that is a correct statement or not, the fact remains the same—that the writer has not found any *E. sinuata* var. *bactriana* in Kansas.

It is not necessary to redescribe the procephalon and dorsum of this species, as it agrees with that given in the generic characters. The sides of the prothorax bear three lateral carinæ, the central one being branched at its base in such a manner as to frequently appear as two. The lower one forms the edge of the prothorax, while the upper branches into the posterior elevations. These carinæ frequently appear white, especially in the males. There is a prominent dorsal carina which extends from the base of the metopidium, follows the elevations in their sinuations, and finally fades out on the posterior process. The prothorax extends beyond and covers the tips of tegmina. The tegmina are transparent except in the basal region of the three longitudinal veins in the corium; this region is dark and heavily coriaceous. The discoidal cells are small and pushed costad and distad, leaving the lower part of the corium unveined. The tips of the tegmina are infuscated. The suprahumerals are distinct, obtuse, and not formed by any marked invaginations in the outline of the prothorax.

The male is dark, almost black, with procephalon slightly less elevated than in the female. The face heavily punctate. As a rule, the male is smaller than that of the female. The female is light brown or tan, mottled with dark anteriorly. The front of the head and procephalon is densely spotted with irregular dark markings, and there is an arcuate dark mark on the sides of the prothorax behind the middle, with the posterior end infuscated. The body usually accords in shade to the main color of the prothorax; the legs pale. There are variations in this color marking, as the front of the face and prothorax, including the cephalic elevation or procephalon, may be pale, as usual, but the sides of the prothorax, including the dorsal hump, may be very dark, the caudal third of the prothorax being light, infuscated at the extreme

tip. Legs pale; body dark. Sometimes the color markings do not take definite shape, but appear in mottled splotches. Again, the procephalon may be light in color, continuing on to the sides of the prothorax and forming a cephalocaudal band meeting the light caudal third, thus leaving only the tip of the cephalic elevation and the sides of the dorsal elevation dark.

Length: Males, 3.3 to 5.1 mm.; females, 5.2 to 6.1 mm. Described from sixty-three specimens.

HABITAT: Manchester, Vt.; Maine; Kansas City, Mo.; Brownsville, and Galveston, Tex.; Douglas, Sedgwick, Reno and Neosho counties, Kansas; New York.

Synonyms:

1798—*Membracis sinuata* Fabr. Ent. Syst. Suppl.
1798—*Membracis emarginata.*
1803—*Membracis emarginata* Fabr. Syst. Phyng.
1851—*Entylia concisa* Walk. List. Hom. B. M.
1851—*Entylia decisa* Walk. List. Hom. B. M.
1851—*Entylia accisa* Walk. List. Hom. B. M.
1851—*Entilia torva* var. Fitch. Cat. Hom. N. Y.
1851—*Entilia torva* Walk. List. Hom. B. M.
1876—*Entilia carinata* Glover. Rep. U. S. Dept. Agril. No. 29.

At the close of the Synonimical Catalogue occurs the following habitat: New York, Missouri, New Hampshire, Virginia, District of Columbia, South Carolina, North Carolina, Pennyslvania, Michigan, Iowa, Maryland, Florida, Illinois.

3.—Genus *Publilia* Stal.

This genus has been formed by Stal for the reception of those species formally classed as *Entylia,* where the elevations are not high enough to put the form strictly into genus *Entylia,* but in which the dorsum is similarly sinuated. Kansas contributes two species to the genus.

A. Dorsum straight or feebly bowed, scarcely if at all sinuated, form slender, prothorax punctate, not wrinkled .... 2—*modesta* Uhler
AA. Dorsum elevated, obviously sinuated.
B. Sides of the prothorax with longitudinal wrinkles which form a network along the dorsum .... 1—*concava* Say

1.—*Publilia concava* Say. Figs. 26, 27, 65.

A small, dark form with a very roughly punctated and coarsely reticulated pronotum, which almost covers the tegmina laterally. The metopidium is slightly elevated, being compressed and in cephalic aspect appears as a heavy carina or minute procephalon above the cephalic face of the metopidium. The sinus on the dorsum is obvious, although not as marked as in *Entylia sinuata;* the base is flat or angulated, not a regular curve. The dorsal crest is not abrupt caudad, but curves gently to the posterior process. Along the sides of the prothorax are distinct carinæ, which become forked anteriorly and dorsally, forming a network of veins.

This species is dark, mottled slightly with pale, and there is a light vitta on the side below the sinus, and a large spot on the lateral edge behind the middle, extending upward toward the dorsal crest, but not

extending to it. At the back of the dorsal crest is a narrow transverse line of a pale color, or there may be a reticulation.

Length, 6 to 5 mm. Described from ten specimens.

HABITAT: Maine; Kansas City, Mo.; New York; Douglas county, Kansas.

2.—*Publilia modesta* Uhler. Figs. 32, 33.

A comparatively pale species, with prothorax entirely covering the abdomen and tips of tegmina, leaving only the costal region exposed. The dorsal sinus is very slight, sometimes almost entirely absent. The metopidium is not elevated into a procephalon of any degree, but is transversely rounded, the dorsal crest not apparent. Dorsum only slightly arcuated. Body dark, with femora black and shiny; frequently body light and legs pale. Pronotum with lateral carinæ indistinct, and very slight, if any, reticulation; closely punctate.

Color variable. There are some individuals which are pale green, with only the front of head and metopidium mottled with dark, or the form may be brownish, with face still darker. The sides of the prothorax with two pale spots, one large one near the front, and an oblique line near the posterior process, concurrent across the dorsum. Frequently these pale spots are a light yellow. There is a white or grey variation, with head and front of metopidium dark grey, the posterior process and an oblique band on the prothorax also grey. A few forms are almost pure white, being only inconspicuously mottled, and this on the dorsal carina. In these vary pale specimens the costal region of the tegmina is the same shade as the ground color of the pronotum, and is coriaceous.

The nymphs have sharp, shiny dorsal tubercles on the abdomen. The enlargements of the head and prothorax are hirsute. *P. bicinctura* Godg., as determined in F. H. S. collection, appears to agree with the grey variation of *P. modesta*.

Length, 4.5 to 5.1 mm. Described from seventeen specimens.

HABITAT: Albuquerque, N. M.; Colorado Springs, Colo.; Gove and Rawlins counties, Kansas.

4.—Tribe SMILIINI Goding.

In this tribe we find four genera—*Smiliia* Germ., *Ophiderma* Fairnm., *Antianthe* Fowler, and *Cyrtolobus* Goding. Of these, only *Cyrtolobus* is reported from Kansas. The last three genera are separated from the first, *Smiliia*, by the presence of a transverse nervule between the two inner longitudinal veins, which is absent in *Smilia*. *Cyrtolobus* and *Antianthe* are separated from *Ophiderma* by the strongly compressed pronotum, as *Ophiderma* is not at all compressed and the dorsum is rounded transversely. Again, *Cyrtolobus* is differentiated from *Antianthe* by the absence of the strongly produced suprahumerals so evident in *Antianthe*. In *Cyrtolobus* there are small suprahumerals and the dorsum is highest at about the middle.

Students in this subject have seen fit to divide the genus *Cyrtolobus* into the subgenera *Xantholobus* V. D., *Evashmeadea* Godg., *Atymna* Stal, and *Cyrtolobus* Godg. *Xantholobus* is separated from the others by its posteriorly inflated pronotum. *Atymna* and *Cyrtolobus* differ from

Evashmeadea Godg. by the lack of sinuation on the dorsal crest. *Atymna* and *Cyrtolobus* are differentiated by the position of the highest portion of the crest. In *Atymna* the highest portion of the crest is anterior to to dorsum, rising above the humeral angles, while in *Cyrtolobus* the highest portion of the crest is near the middle of the dorsum.

Of this subgenus Kansas has recorded but one species, *Cyrtolobus vau* Say. Figs. 24, 25, 79.

This species is pale brown or tan; frequently banded with both darker and lighter shades than the ground color. The crest is evenly arcuated, and in some cases very little elevated. The metopidium is transversely rounded, the crest beginning to rise back of the humeral angles. The dorsum is rounded from its ventral edges and the crest is formed by a sharp compression. At times this crest is made manifest only by a distinct and prominent median dorsal carina. The pronotum does not extend to the tips of the tegmina, but covers the abdomen. The carina is usually darker than the rest of the pronotum. The color marking, when present, consists of three dark spots along the lateral side of the dorsum, cut into by two streaks of light on the crest or carina, but joined together on the lower edge of the side of the dorsum. Posterior process is light if the color markings are present; otherwise it is light and concolorous with the pronotum. The face is usually void of color markings, and is short, with a broad clypeus rounded at the apex, and black, shiny, compound eyes. Legs pale and slender; pectus pale. Tegmina distinctly veined and transparent except near the tip, where it commences to become smoky, and continues so to the very tip.

Length, 6.5 to 5 mm.

HABITAT: Colorado Springs, Colo.; Kansas City, Mo.; Columbia, Mo.; Pennsylvania.; Douglas county, Kansas.

II.—SUBFAMILY MEMBRACINÆ STAL.

This subfamily is differentiated from the others by the dilated or foliaceous tibiæ. In this subfamily are placed the two genera *Enchenopa* and *Campylenchia*, which together are separated from the other members of the subfamily by the pronotum being distinctly compressed and elevated toward the front into a prominent, usually oblique process. This process is further characterized by the lateral carinæ attaining the middle of the posterior process.

The two genera are separated from each other by the position of the lateral carinae:

A. Lateral carinæ of the anterior process simple, placed about equally distant from the upper and lower margins. Carinæ foliaceous. Pronotum without pubescence. 1—*Enchenopa* A. & S.

AA. Lateral carinæ of the anterior process with several branches. Carinæ placed a little nearer the dorsal margin; the inferior carina not foliaceous. Pronotum with appressed pubescence .... 2—*Campylenchia* Stal

1.—Genus *Enchenopa* A. & S. Figs. 12, 13, 71, 85.

In this genus Kansas has recorded but one species. This one, however, is very common and of wide distribution. *Enchenopa binotata* Say may be distinguished from the other species of this genus by its dorsal carina being very prominent posteriorly. The insect is of a reddish brown, while

its near relative, *permutata*, is pale yellow. The color of the prothorax may at times be almost black. The dorsal carina is extremely elevated and continues prominent to the tip of the posterior process.

The metopidium bears a procephalon or anterior horn, which is usually larger at its anterior extremity than where it joins the pronotum. This horn seems to rise obliquely forward from the pronotum for some distance and then turn suddenly forward in a line parallel with the dorsal carina, thus forming a "bump" at the end of the horn. The procephalon is distinctly compressed, and the dorsal carina extends into the procephalon and follows the median line even into the cephalic face.

On the sides of the prothorax, but so close to the dorsal carnia that they extend over and meet the spots on the opposite side, are two long, slender spots, extending for some distance laterally. This is the character which probably gives the species its name. The posterior process is dark and very acute. The tegmina are entirely dark reddish brown with a smoky translucency. The wings are transparent. The body and pectus dark reddish brown. The tibiæ of the prothoracic and mesothoracic legs are dilated; the metathoracic grooved on its outer side and spined along the two outer edges.

Described by Buckton as *Enchenopa prorecta*, and by Walker as *Enchenopa brevis*.

Length, 5.5 to 7.4 mm. Described from over 100 specimens.

HABITAT: Missouri; Pennsylvania; Taxas; Manchester, Vt.; Canada; Douglas and Sedgwick counties, Kansas.

2.—*Campylenchia curvata* Fabr. Figs. 70, 11, 86.

This species is a dusky reddish brown, with a procephalon or horn protruding obliquely over the face for a distance about equal to the pronotum, measuring from the suprahumerals posteriorly. The dorsal carina is not greatly elevated, but the lateral carinæ are distinct and extend from the tip of the procephalon into the posterior process, which is acute. The pronotum is concolorous; the tibiæ, as in *Enchenopa binotata*, are dilated. The tegmina smoky, coriaceous in the costal region and on the basal cells. Pectus dark and eyes light.

Length, 8 to 9 mm. Described from over 100 specimens.

HABITAT: Colorado; Missouri; Canada; Douglas county, Kansas.

INDEX TO SPECIES.

FOOD PLANTS.

Ceresa bubalus.
Osage orange .... *Maclura aurantiaca* Nutt.
Horse radish .... *Nasturtium armoracia* Fries.
Gama grass .... *Tripsacum dactyloides* L.
Sunflower .... *Helianthus annuus* L.
Alfalfa .... *Medicago sativa* L.
(Reported by Riley on apple and potato.)

Acutalis tartarea.
Horse ragweed .... *Ambrosia trifida* L.

Ceresa taurina.
Horse radish .... *Nasturtium armoracia* Fries.
Choke cherry .... *Prunus arbutifolia* L.

Ceresa diceros.
Elderberry bushes.

Campylenchia curvata.
Goldenrod .... *Solidago canadensis* L
Sensitive rose .... *Cassia nicitans* L.

Enchenopa binotata.
Goldenrod .... *Solidago canadensis* L.
Pin oak .... *Quercus palustris* Du Roi.
Bittersweet .... *Solanum dulcamara* L.

Entylia sinuata.
Sweet clover .... *Melilotus alba* Lam.
Thistle .... *Cnicus altissimus* Willd.
Cat-tail grass .... *Phleum alpinum* L.
Sunflower .... *Helianthus annuus* L.
Alfalfa .... *Medicago sativa* L.
Spikenard .... *Ambrosia* sp.

Publilia concava.
Pin oak .... *Quercus palustris* Du Ror.
Sycamore .... *Platanus occidentalis* L.

Publilia modesta.
——— .... *Berlandiera texana.*

Stictocephala inermis.
Gama grass .... *Tripsacum dactyloides* L.

Telamona ampelopsides.
Woodbine or Virginia creeper...... *Ampelopsis quinuefolia* Michx.

Alfalfa .... *Medicago sativa.*
Ceresa bubalus.
Entylia sinuata.

Berlandiera texana.
Publilia modesta.

Bittersweet .... *Solanum delcamara.*
Enchenopa binotata.

Cat-tail grass .... *Phleum alpinum.*
Entylia sinuata.

Choke cherry .... *Prunus arbutifolia.*
Ceresa taurina.
Gama grass .... *Tripsacum dactyloides.*
Ceresa bubalus.
Stictocephala inermis.
Goldenrod .... *Solidago canadensis.*
Campylenchia curvata.
Enchenopa binotata.
Horseradish .... *Nasturtium armoracia* Fries.
Ceresa bubalus.
Ceresa taurina.
Osage orange .... *Maclura aurantiaca.*
Ceresa bubalus.
Pin oak .... *Quercus palustris.*
Enchenopa binotata.
Publilia concava.
Sweet clover .... *Melilotus alba.*
Entylia sinuata.
Sensitive rose .... *Cassia nictans.*
Campylenchia curvata.
Sycamore .... *Platanus occidentalis.*
Publilia concava.
Sunflower .... *Helianthus annuus.*
Ceresa bubalus.
Entylia sinuata.
Thistle .... *Cnicus altissimus.*
Entylia sinuata.
Virginia creeper .... *Ampelopsis quinquefolia.*
Telamona ampelopsides.
Woodbine—See Virginia creeper.

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TABLE OF CONTENTS.

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Vol. VIII, No. 4] JULY, 1913. [WHOLE SERIES VOL. XVIII, No. 4.

The Larridæ of Kansas.

BY FRANCIS X. WILLIAMS.

(Submitted in partial fulfillment of the requirements for the degree of Master of Arts at the University of Kansas.)

Plates XXII to XXX.

INTRODUCTION.

THIS paper is the result of about two years of study on that group of insect-catching wasps known as the Larridæ. The work done embraces the field observations and collections of three consecutive summers (1910-'12), spent chiefly in the western portion of Kansas; a large amount of laboratory work at the University; and a trip to the United States National Museum and Philadelphia Academy of Sciences during the winter of 1912-'13.

It may be here stated that the Larridæ belong to the order Hymenoptera, and constitute one of the families of a large series of wasps known as the Fossores, or *digger wasps,* so named because of their habit of excavating burrows in the earth. The Fossores in turn are included in and form the largest portion of that great assemblage, the *solitary wasps.* These are distinguished from their *social* brethren by having the species represented only by the male and the fully developed female, whereas the latter group possesses three castes or forms—males, egg-laying females, and undeveloped females, or workers. Furthermore, each female solitary wasp constructs and uses her own nest, unless parasitic, while social wasps have one common abode, and are therefore of communal habit.

The Larridæ are rather stoutly built insects, for the most part of somber coloration, and, in the United States, range from about one-eighth of an inch to nearly an inch in length. Being very swift of movement and inobtrusive in habit, they are seldom seen by the the casual observer. Generally speaking, they store their burrows with long- or short-horned grasshoppers, crickets, and bugs, which are subdued by stinging. The wasp lays an egg in each provisioned cell, closes it, and then leaves her offspring to work out its own salvation in this dark chamber. Upon hatching, the grub devours the food provided (this is often in a decomposing condition), and reaches maturity, to spin or form a sort of cocoon. From this cocoon the wasp emerges in due season, to continue the life-cycle.

Those of us who have not had the good fortune, the patience or the inclination to watch one of these digger wasps at work have missed the opportunity of observing an insect of remarkable instincts, great perseverance, and notable temerity in attacking its often huge prey. Few persons have any idea of the vast amount of good done by these Hymenoptera, for the noxious insects destroyed by the solitary wasps is very great, and plays an important part in maintaining the balance in nature.

The external anatomy of the large species, *Tachytes distinctus,* which is worked out in this paper, has presented features of interest to the writer, while the classification of the group, because of its ill-defined limits and the close relationship which many of the species (of which fifty-eight have been found in Kansas) bear to one another, is rendered at the same time both attractive and perplexing.

This paper is of necessity far from complete, particularly so is the chapter devoted to biology; nor can the writer hope that it is free from errors.

The identifications have been made with care, and if the status of a species is uncertain it is so indicated in the text. The types of the new species are in the Snow entomological collections, at Kansas University, at Lawrence.

While in most cases the keys are largely modifications of those of Sharp, Cresson, Fox, Ashmead, and others, the writer frequently emphasizes characters heretofore but little used in classification in the American keys to species, so that this portion of the work is not lacking in originality. The generic and often the specific descriptions are in a great measure

taken from those in Fox's "North American Larridæ" (Proc. Acad. Nat. Sci. Phil., 1893). These are usually abridged, except in the case of new species, and often refer more particularly to the Kansas specimens.

No attempt has been made to cite much of the literature relating either directly or indirectly to the Larridæ. This is largely because of the inaccessibility of many of these writings, chiefly those of Europe, which are very important, and because of the limited scope of this paper. In the systematic portion reference is made to the original descriptions, and very frequently also to the best or more accessible diagnoses. The drawings are original, often of camera lucida outline, and where possible are made from the type specimen.

In conclusion I desire to extend my thanks to the various members of the Kansas University Entomological Survey who assisted me in the field work; to the officers of the United States National Museum, for the favors extended me while there, especially to Mr. S. A. Rohwer, of that institution, for the very efficient aid given me in identifying species, etc.; to the Academy of Natural Sciences of Philadelphia, for similar kindness, and in particular to Mr. Wm. J. Fox, for copying portions of literature inaccessible to me, and for comparing specimens; to Prof. Myron H. Swenk, of Nebraska University, for the loan of certain Larridæ; to Mr. H. B. Hungerford, of Kansas University, for criticizing the manuscript; and finally to Prof. S. J. Hunter, in whose department this work was done, for many helpful suggestions and for his patience and criticism in going over the manuscript.

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PART I.

The External Anatomy of *Tachytes distinctus.*

Inasmuch as the external anatomy of each genus of the North American Larridæ could not be examined, the writer has selected a large and common species, *Tachytes distinctus*, a typical example of the family, as the basis for the short study herewith presented.

The female of this insect is fully twice as large as our common honey-bee (*Apis mellifica*), of stout build, though rather elongate, and in general of a dull black color, partly concealed by pubescence. The yellowish wings are smoky apically; the legs spinose, and largely of a ferruginous color. The male is smaller, and usually more slender than the female. A specific description of the insect will be found in the systematic portion of this paper, while notes on its habits are given on pages 194-197 (96-101) of the biologic section.

In order to bring to light more clearly the often none-too-well defined areas and sclerites, the pubescence and pile should be removed from the head and thorax of the insect.

HEAD.

(Pl. XXII, fig. 6, front view.)

Areas and Sclerites.

The head of this type of insect does not present the comparatively generalized condition to be found in the cockroach, for example, where some of the sclerites are definitely bounded by sutures. On the other hand, they have very largely disappeared by fusion with one another.

Compound Eyes. The large, greenish compound eyes converge towards the upper portion (vertex) of the head, with the effect of making the interocular space at that point only about one-half as wide as the space between the eyes at the base of the mandibles, to which they nearly extend. This interocular space at the vertex varies in different species, and is for that reason of considerable taxonomic value.

Clypeus. This sclerite occupies the lower portion of the face below the insertion of the antennæ. Its area is indicated by *c* in the figure. Its free (distal) end is prolonged into a lobe, from beneath which depends the labrum (*l*). The boundary between the clypeus and the frons, the next sclerite above, is indicated by a suture, which, extending obliquely upwards from near the base of the compound eyes, proceeds first to the outer side of the antennal sockets, then obliquely downwards to just below the latter, and finally transversely before them. The angle thus formed by these oblique sutures is marked by a small pit, the base of the hollow ingrowth of each mesocephalic pillar or arm of the tentorium, which constitutes the endoskeleton of the head.

Frons. The frons, or front, (*f*) as we have just seen, is bounded definitely below by a suture, but its upper limits are quite disputable, for here it can hardly be said to do more than to give way to the vertex, since the suture between these two areas is obsolete or nearly so. The frons is of course bounded laterally by the compound eyes; it bears the antennæ, and perhaps the anterior ocellus, at least. The sockets into which the antennæ fit are quite proximate; there is a short raised area immediately above them, while laterad of this elevation are the two rather large, smooth antennal fossæ or depressions. There is an interrupted line extending from the upper portion of the head to near the antennal sockets. This is the median line of the head.

Vertex. The vertex is defined in Smith's Glossary of Terms Used in Entomology as "the top of the head between the eyes, front and occiput; in bees that part adjacent to and occupied by the ocelli." If, at least in the more specialized families of Hymenoptera, as the one under consideration, the vertex is to be regarded solely as an area of position, it would occupy the top of the head, as the name would imply, and this, at least in most Larridæ, would place the lower boundary of the vertex about at the top of the paired (posterior) ocelli. Regarding the vertex as a sclerite, we would find in certain Hymenoptera that the median impressed line of the frons often forks at or just before the anterior ocellus, but these branches do not extend laterally to the compound eyes, and thus would not shut off the upwards-extending frons (?) from the vertex. According to Comstock and Kochi (Am. Nat., XXXVI, 28;

1902) we read that, "in the more specialized orders, wherever we have been able to distinguish between the front and the vertex, we have found the paired ocelli in the vertex." The solid line *f*, figure 6, probably represents the upper limit (on the median line) of the frons and the lower limit of the vertex (*vx*), from a morphological point of view, while the paired dotted lines *f* and *vx*, in the same figure, represent these two areas as frequently considered by the systematist. Behind the paired ocelli is a somewhat wedge-shaped depression pointing posteriorly. This may mark the posterior limit of the vertex. This depression is well marked in those genera among the Larridæ having the posterior ocelli distorted, and is apparently associated with that distortion.

Genæ and Occiput. The genæ, or cheeks, refer to that portion of the head behind the compound eyes, and limited posteriorly by the occipital ridge. The occiput is represented by a more or less circular depression* occupying the posterior portion of the head and opening into the foramen magnum, which is the passage for the esophagus, trachæ, etc., from the thorax into the head. It is evident from descriptions of species, and from generic descriptions as well, that at least the dorsal portion of the occiput is not usually considered as confined by the raised line bounding the depression, but that it extends more anteriorly, *viz.*, as far as the line drawn from the posterior borders of the eyes, to meet the vertex.

Ocelli. These are three in number, but in *Tachytes*, as in other typical Larridæ, only the anterior one is rounded, perfect, and presumably functional; the posterior ocelli in the species under consideration are drawn out and curved hook-like behind, where they are quite proximate. A smooth, shining area extends along the outer edge of the attenuated ocelli but does not seem to be a portion thereof, for if the part of the head containing the ocelli be submitted to the caustic action of KOH, and then exposed to light, the nearly circular outline for the anterior ocellus is revealed, while the posterior pair show elongate, imperfectly S-shaped slits.

Appendages.

Antennæ. (Pl. XXVI, fig. 41.) The antennæ, as heretofore noted, arise close together from the frons, just above the clypeus. They consist in the male of thirteen joints, and in the

* This is referred to in Say's American Entomology as the jugulum.

female of twelve. They are conveniently divided into three parts: the scape (*s*), the largest and stoutest of the joints, which is differentiated into a small bulbous basal portion (*b*), fitting snugly into the socket, and the main limb, which is quite densely hairy; the pedicel (*p*), a short joint springing from the scape; and lastly, the flagellum or filament *F*, constituting the remaining many-jointed and commonly uniform portion.

Mouth Parts.

(Pl. XXIII, figs. 7-10.)

The large oral cavity bears the complicated type of mouth parts found in most Hymenoptera. If we consider the clypeus to be the dorsal (upper) edge of the oral cavity, we have depending therefrom, though but little exserted, the labrum. This is indistinctly bilobed, and bears some short, stout bristles. From the ventral (opposite or lower) side of the oral cavity hang the cardines of the maxillæ (fig. 7, *C*), contributing to and supporting the latter, which may in turn partly enclose and protect the median composite labium, or lower lip. The latter, unlike the maxillæ, is not directly secured to the head skeleton, but is separated from it by an intervening membrane.

Epipharynx. (Pl. XXIII, figs. 8 and 10, *EPH.*) The epipharynx is a slightly bilobed and pilose membrane which hangs down from the base of the labrum. Laterally it is protected by a thin, weakly chitinized plate, which extends for a short distance into the mouth opening. The epipharynx may be termed the roof of the mouth. At the pharyngeal entrance is the pharyngeal plate, which is opposite the epipharynx. It is a transverse chitinized piece, extending from each side anteriorly as a pair of broader subparallel portions, and posteriorly as a narrow pair (fig. 10, r), which converges to the œsophagus. These (*r*) are termed by Sharp the epipharyngeal sclerites. The piece *s*, figures 8 and 10, is stouter than *r*, and extend from the dorsal (under) side of the mentum (*M*) up to the anterior of the pharyngeal processes. The pair *s* is termed by Sharp the hypopharyngeal sclerites, and would seem largely to support the oral tissue, and in a great measure keep the mouth cavity open when necessity demands.

The mouth parts thus far described do not differ very materially from those of the bumblebee as given by Sharp (Camb. Nat. Hist. Ins., II, 14; 1901).

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Maxillæ. (Pl. XXIII, figs. 7, 9 and 10.) The maxillæ closely appress the labium on either side. They are of rather complicated structure, in that they are composed of a number of separate sclerites. As with the same structure in the honeybee (*Apis*), the distal part in *Tachytes* is considerably shortened, though, if anything, more complex in the wasp.

Lorum. The lorum, which is conspicuous enough in *Apis* and *Bombus* (among others), could not be made out with certainty here. It is possible that each lorum is represented in *Tachytes* by that broad upper inner portion of the cardines which is here thin and less heavily chitinized than the lower part, though it is in no wise separated therefrom. (See pl. XXIII, fig. 9, *N* and *C.*)

Stipe. (Pl. XXIII, figs. 7, 9 and 10, *St.*) Articulated to the distal end of each cardo is the stipe, which comprises the largest portion of the maxillæ. Figure 9 represents an inner view of one of the maxillæ; it will be observed that the stipe is heavily chitinized and composed of several pieces. Near the tip of each stipe arises the large six-jointed maxillary palpus.

Galea. (Pl. XXIII, figs. 7, 9 and 10, *MX.*) The large blade-like galea of the honeybee is here represented by a short, stout lobe articulated to the stipe. It is armed with stout as well as with fine hairs.

Lacinia. (Pl. XXIII, fig. 9, *L.*) Arising from a spur of chitin on the inner side of the galea, near its distal extremity, is a well-formed, curved lobe, which would seem to represent the lacinia. When in position, each of these lobes is seen to overlie the more basal of the two dorsal pairs of chitinized lobes or scales of the labium. (See pl. XXIII, fig. 8, *k.*) MacGillivray (Ann. Ent. Soc. Am., V, No. 3, 231-8; 1912) describes and illustrates the lacinia in several groups of Hymenoptera, where, as in *Tachytes,* it consists of a thin pilose lobe far smaller than the galea. The inferior, distal edge of the stipe and the basal portion of the galea are thin and flap-like (fig. 9).

Labium. (Pl. XXIII, figs. 7, 8 and 10.) Commencing from its base, the labium is composed of the submentum (*SMt*); mentum (*M*); and the ligula, which comprises the fused glossæ (*GL*), the paraglossæ (*PGL*), and several small sclerites. The submentum is a small, delicate, V-shaped sclerite lying in

the membrane between the stipes, cardines and mentum. It does not appear to be articulated to or otherwise connected with the large mentum, but lies immediately behind it. The mentum is the large, heavily chitinized piece forming the body of the labium. Just before and on each side of its wedge-shaped extremity are the four-jointed labial palpi (*LP*). On either side, at about the middle of its length, the mentum sends an extension dorsad, which is secured in a degree to the inner lateral edge of the stipe of the maxillæ.

Glossa. Anterior to and arising from the mentum is the largely membranous ligula, consisting of the fused glossæ and the free paraglossæ. It is tongue-like at its tip (labellum). At the base of the ligula is the translucent ventral supporting plate of the ligula, which is grooved to the extremity of the ligula (fig. 7, *gl, gr*). The dorsal extremity of the latter (fig. 8, *GL*) is beset with rather appressed, apically expanded hairs arranged in transverse rows.

Hypopharynx. The glossæ are sometimes termed the hypopharynx, but Snodgrass (Anat. of the Honeybee, U. S. D. A. tech. ser. No. 18, pp. 49-50; 1910) has shown that the honeybee does not possess a hypopharynx. To quote this author: "The duct of the salivary glands of insects in general opens upon the base of the labium in front of the hypopharynx. In the honeybee the salivary opening is on the dorsal side of the base of the ligula, between the paraglossæ. . . . This alone would show that the glossa is not the hypopharynx of the bee, as many authors have supposed, for otherwise the opening of the salivary duct should be ventrad to the base of the glossa. In fact, this makes it clear that the bee does not possess a hypopharynx. There is, however, a conspicuous chitinous plate located on the anterior part of the floor of the pharynx, having two terminal points hanging downwards over the lower lip of the oral aperture; but, although this plate is truly hypopharyngeal in position, it is not the homologue of the organ called the hypopharynx in other insects."

This statement appears to apply as well to *Tachytes*, which has the opening of the salivary glands similarly situated between the scales of the paraglossæ (pl. XXIII, fig. 8, near *h*). The portion above and beyond the mentum, being largely membranous, bears several strengthening sclerites of small size (pl. XXIII, fig. 8, *g, h, e*); *g*, the most anterior of these, lies

at the dorsal base of the glossæ and is somewhat V-shaped in cross section, sending out a ventral arm (*f*) to either side to connect the piece with the thin paired plates (*e*, figs. 7 and 8). These are situated at the base of the mentum and are also connected with the two lateral pieces (*d*). There is, in addition, a more or less central arched piece, through the curve of which the tube of the salivary glands passes.

Paraglossæ. (Pl. XXIII, figs. 7 and 8, *PGL.*) These arise from the two partly free dorsal chitinized lobes (*i*), and extend ventrad on either side as thin transparent processes (fig. 8, *PGL*). The curved sclerite (*h*) lies in the inner membrane of the piece *i*, and is secured to *g* near the base of its posterior arm (*f*).

Mandibles. (Pl. XXIII, fig. 7, *MD*, base; pl. XXV, figs. 21 and 22.) These are large and stout, bidentate within, and with a distinct emargination exteriorly (on the lower side) before the middle. In the male the mandibles are more slender than in the female.

How Food is Taken.

It may be well to mention, in the first place, that this process was not observed; the writer having given the mouth parts considerable study, believes that his views are correct. To see how food is taken up by the mouth parts and conveyed to the œsophagus, constant reference must be made to figures 8 and 11. The former figure we have just considered; the latter is a somewhat diagrammatic dorsal view, chiefly of the labium. As before stated, the epipharynx hangs down as a lobe from the labrum, while ventrad of (opposite) the former is the floor of the pharynx. It is between these two, therefore, that the passage (*o*) to the esophagus extends. The anterior end of the pharynx (*p*, fig. 11) is free; that is, extends forward as a horizontal, let us say, lobe, below and behind which is a thin-floored blind sac or pouch (*t*, fig. 8). Between the paired lobes *i* and *k* is a longitudinal channel or groove (fig. 11), which terminates posteriorly just before the aforesaid lobe (*p*). The ligula at this point slopes down rather abruptly (*x*, fig. 11); this is just about ventrad of *p*, figures 8 and 11, the slope ending in the form of an emargination or arc (*c*), with its center or inclined floor (as viewed from above) directed anteriorly. The anterior edge of the pharyngeal lobe (both figures) can be made to fit this emargination or curve

very nicely (for here the membrane, falling off steeply, allows the lobe *p* to rest flush or coincide with *c*, figure 11), and when serving such a purpose shuts off the passage (*b*) to the blind sac below. By comparing the two figures with one another and following the arrows in figure 11, commencing with the apical arrow (*A*), which is seen departing from the ventral groove of the ligula (as seen in figure 7, *gr*), and keeping in mind that the dotted portions of the arrows are below or behind the transverse lines which they intersect, it can be seen how nectar or other liquids may by a ventral-to-dorsal route be drawn, presumably by capillarity, into the mouth opening (*o*). If the insect raises the pharyngeal lobe, the lower passage *b* (fig. 11) leading to *t* (fig. 8) is opened; the latter is frequently found filled with pollen, which is probably taken at or near the pouch, and does not follow the same initial course as the liquids.

The glossa, of course, can be lengthened or shortened by the insect by blood pressure and the action of muscles, this action playing an important part when the wasp is taking food.

THORAX.

(Pl. XXII, fig. 1, lateral view; fig. 3, dorsal; fig. 4, ventral.)

The compact form as well as the hardness of the thorax does not permit its three divisions to be as readily determined as one would desire, while the fusion of the first abdominal segment (*IT*) with the thorax has led many systematists into the error (or convenience?) of considering the former a part of the metathorax. The latter is here the smallest division of the thorax.

Prothorax (*1*). This is of moderate size, but comparatively larger than in the honeybee, and somewhat drawn in under the scutum of the metathorax. Its notal (dorsal) portion has a transverse anterior notch, while a second notch behind the first divides the prothorax into the proscutum and proscutellum. The proscutum forms a complete ring, which narrows ventrad, while the proscutellum terminates apparently at the shoulder tubercles (*L*). The latter are also known as the *prothoracic lobes* or *posterior lobes* of the pronotum. They protect the first thoracic spiracles, and are of some importance in the classification of the Hymenoptera into the larger divisions or series. Fernald (Chlorioninæ of N. A. and West Indies, Proc. U. S. N. M., XXXI, p. 300; 1906) terms the anterior

dorsal and lateral division of the prothorax the *neck,* and the more elevated posterior portion the *collar*. The pleural or side sclerites (propleuron) are represented by the large episternum (*Eps*), which is partly covered by the overlapping pronotum.

Mesothorax (*2*). This is the largest of the three thoracic divisions. Dorsally it is composed of the convex scutum (*Sct*), and the succeeding shorter piece, the scutellum (*Scl*). These combined constitute the mesonotum. From the anterior borders of the scutum, posteriorly, run the parapsidal furrows. The scale-like tegulæ (*tg*) which cover the base of the fore wings are situated under the lateral edge of the scutum. The pleural portion of the mesothorax consists of the large anterior episternum (*Eps*) and the more posterior epimeron (*Epm*). The episterna do not meet on the mid-ventral line, as do the epimera, for their whole length (fig. 4, *Epm*); there is therefore no suture in this case separating the pleural from the sternal portions. The mesosternum proper (*S*, fig. 4) is situated caudal of the epimera and between the middle coxæ.

Metathorax (*3*). This is very small. Dorsally it consists of the wing-bearing notum (*N*), behind which is the yet smaller postnotum. The side of this segment (*pl*) is evidently not divided into the two usual pieces by suture, such as exists in the mesothorax. The small, grooved metasternum lies immediately behind the larger metasternum.

APPENDAGES OF THE THORAX. *Wings.* (Pl. XXIV, fig. 14.) The wings are inserted between the notal and pleural elements of the mesothorax and metathorax, respectively, and inasmuch as the fore wings are the chief organs of flight the mesothorax is strongly developed at the expense of the inconspicuous metathorax.

The veins (fig. 14) and the cells (fig. 15, *Tachysphex propinquus*) follow the usual nomenclature, the lettering being from Fernald's Chlorioninæ. The system is comparatively simple, and while it may not be as logical as some others, it is easily remembered and applied, and for that reason used here. An enlarged figure of the inner margin of the primaries (pl. XXV, fig. 33) shows the fold for the reception of the hooks on the costal margin of the secondaries. One of these hooks is illustrated in figure 12. By this device the wings are united to move in unison.

Legs. (Pl. XXII, fig. 5, posterior leg of female; pl. XXVIII, figs. 83 and 85, femur of male.) These are stout and spinose, more so in the female than in the male. The fore legs are used largely for digging. The fore and middle tibiæ each bear but a single apical spur (calcar), while the hind tibiæ have two. These spurs are fringed inwardly with short, stiff hair; those of the anterior pair have the basal portion emarginate inwardly and armed there with a short comb, which, coöperating with a similar one in an emargination at the base of the first tarsal joint, serve as antennal cleaners, the antennæ being drawn between them. This structure is show in figure 88, in the genus *Notogonia.* Figure 89 shows this modification in *Astata,* which is sometimes classified with the Larridæ, but is perhaps more allied to the Nyssonidæ. Notice that the spur is here bifurcate, while it is simple in all the Larridæ which I have examined.

The male of *Tachytes distinctus* has each fore coxa armed inwardly with an elongate process, which bears some bristles apically (pl. XXIII, fig. 13 *H*). while the fore femora of the same sex are excavate on the under side near the base; these conditions are good examples of secondary sexual characters, and do not occur in all the species of the genus *Tachytes.*

ABDOMEN (fig. 2). *Propodeum* (figs. 1 and 3, *IT*). This portion is also known as the median segment, and erroneously as the metathorax (in part). Inasmuch as it is the first abdominal segment, the author sees no reason for calling it a part of the thorax; therefore, the word propodeum is here used for that part morphologically belonging to the abdomen, however much it may appear to be a portion of the thorax, while what is really the second abdominal segment will in the taxonomic portion of this paper be referred to as the first segment of the abdomen. The abdomen, including the propodeum, has seven visible segments in the female and eight in the male. The second segment, though tapering narrowly to the propodeum, is practically sessile; the next two segments are the widest; the last one in the female has a more or less wedge-shaped disc bounded laterally, except at the base, by a carina, and covered with an even appressed pubescence. This surface is known as the pygidium (fig. 2, *pg,* and 92), and is of considerable taxonomic importance; it is a generic as well as a specific character. Beneath the pygidium is the sheathed sting. The male has a smaller, blunter pygidium, while the eighth ventral segment is well emarginate (fig. 111).

As has been remarked, the species just considered is a typical example of the family. In studying the various Larridæ it will be found that certain groups depart rather widely in a number of anatomical points from the genus *Tachytes*. For example, certain Larridæ have three perfect ocelli, others lack the pygidial area, while the shape of the head and thorax and the neuration of the wings may differ to a considerable degree, to say nothing of size. These various characters are noted in the systematic portion of this paper, in the keys and generic descriptions.

PART II.

Systematic Larridæ.

The following keys will serve to separate the family Larridæ from other aculeate wasps:

Fore wings longitudinally folded in repose...........Series DIPLOPTERA
Fore wings not longitudinally folded in repose.........Series FOSSORES

FOSSORES.

Pronotum and tegulæ in contact; a transverse chink between ventral abdominal segments 1 and 2...........SCOLIIDÆ and MUTILLIDÆ
Pronotum and tegulæ in contact; no transverse chink between ventral abdominal segments 1 and 2.......................POMPILIDÆ
Pronotum and tegulæ not in contact.....SPHEGOIDEA (SPEGIDÆ *sens. lat.*)

SPHEGOIDEA.

1. Middle tibiæ with two apical spurs..SPHEGIDÆ, NYSSONIDÆ, STIZIDÆ, MELLINIDÆ
   Middle tibæ with but onc apical spur or with none............... 2
2. Abdomen with a strong constriction between first and second segments, the first segment much narrower, therefore, at apex than the second ....PHILANTHIDÆ
   Not having the above characters.............................. 3
3. Abdomen elongate and clavate, the first segment petioliform; eyes deeply and narrowly emarginate within; fore wings with usually but one well-defined submarginal cell.........TRYPOXYLONIDÆ
   Abdomen not as above; eyes never deeply emarginate within...... 4
4. Only one complete submarginal cell in the primaries; head very robust, subquadrate; metathorax sometimes spinose..CRABRONIDÆ
   At least two complete submarginal cells in the primaries, the second of these cells sometimes petiolate; head normal, rarely very stout; metathorax never spinose.......................... 5
5. Abdomen petiolate or subpetiolate, the petiole or subpetiole (which is often quite short) distinctly marked off from the remainder of the abdomen, not cylindrical; first discoidal cell of fore rarely if ever longer, usually distinctly shorter, than the marginal cell; marginal cell lanceolate, its apex pointed on the costal margin of the wing; two submarginal cells, the second not petiolate; stigma strong, often very marked; ocelli perfect.....PEMPHREDONIDÆ
   Abdomen tapering to a point at its junction with the thorax; subpetiole, if present, not clearly differentiated from the rest of the abdomen; first discoidal cell of primaries usually distinctly longer than the marginal, which is more often truncate or rounded at apex; two or three submarginal cells, the second sometimes petiolate; ocelli variable.................................. 6

6. Labrum large, longer than wide, conspicuously exserted; ocelli aborted, represented by cicatrices; mandibles not notched beneath; transverse-median nervure of hind wings sinuate or somewhat ∽-shaped .... BEMBECIDÆ
   Labrum small, largely or entirely hidden beneath the clypeus; at least the anterior ocellus perfect; mandibles frequently notched beneath; marginal cell of fore wings usually appendiculate at apex; transverse-median nervure of hind wings straight; not ∽-shaped; fore tibial spur not furcate................ LARRIDÆ

The Larridæ have a world-wide distribution. They are well represented in the temperature zones of both hemispheres. A large number of species have been described from the oriental Region. Some of the neotropical species are conspicuous for their size and coloration.

The limits of the family are not clearly defined, so that the group may be said to be in an unstable condition. Kohl, Sharp and others treat it as a subfamily or group of the Sphegidæ, but Cresson, Ashmead, and Mercet (in Spain) are among those who give these wasps full family rank.

The writer has not examined all of the genera of the North American Larridæ, and has seen but few extra-American species. For this reason he is not prepared to enter at any length into its family characteristics, and consequently bases his conclusions very largely upon North American species and literature. As considered here, the genera *Trypoxylon* and *Pison* (which have deeply emarginate eyes and the abdomen subclavate), *Dienoplus, Astata, Dinetus* and *Diploplectron* (which have the middle tibiæ with two apical spurs), sometimes considered as belonging to the family, are here excluded from the Larridæ.

The type of the genus *Larra* and of the family Larridæ is *Larra anathema* (Rossi), a large, handsome species of the Old World, and not differing greatly from our own *Larra analis.*

The family can be conveniently divided into two groups or subfamilies:

Those having the posterior ocelli imperfect—Larrinæ.

Those having three perfect ocelli; these may be called Atypical Larridæ. The type genus belongs to the Larrinæ.

KEY TO THE GENERA OF KANSAS LARRIDÆ.

1. Three perfect ocelli 2
   The two posterior ocelli more or less distorted 7
2. Second submarginal cell petiolate; mandibles entire or excised beneath; small forms 3
   Second submarginal cell not petiolate; mandibles excised beneath; larger forms .... *Lyroda*
3. Only two submarginal cells; marginal cell not appendiculate, acute at apex 4
   Three submarginal cells 5
4. Two recurrent nervures ....*Miscophus*
   Three recurrent nervures ....*Miscophinus*
5. Mandibles strongly excised beneath; pygidial area of ♀ well defined, broad and shining; clypeus of ♂ with a fringe of hair on either side ....*Plenoculus*
   Mandibles not or very feebly excised beneath; pygidium of ♀ hardly or not shining 6
6. Hind femora thickest apically; pygidial area well defined, pilose in both sexes; marginal cell lanceolate, not appendiculate. *Bothynostethus*
   Hind femora normal, more or less fusiform; pygidial area poorly defined or lacking; marginal cell usually truncate and appendiculate at apex ....*Niteliopsis*
7. A transverse swelling or ridge before the superior ocellus, thereby forming an angle with the upper portion of the head and the front; posterior ocelli quite small, sometimes indistinct, proximate and transversely arranged or nearly so; a long facial depression on each side of the frons for the reception of each antenna; fore femora of ♂ not emarginate beneath near the base 8
   A more or less dome-shaped circular swelling behind the anterior ocellus (no transverse swelling before it); posterior ocelli larger, oblique to nearly longitudinal in position; forehead rounded; fore femora of ♂ emarginate near the base, except in some *Tachytes* 9
8. Mandibles distinctly dentate within; pronotum hardly depressed beneath the level of the mesonotum; posterior margin of the pronotum nearly straight (transversely); pygidium of ♀ practically bare ....*Larra*
   Mandibles more or less distinctly bidentate within; pronotum somewhat depressed beneath the level of the mesonotum; posterior margin of pronotum angled mesad into the mesonotum; pygidium pubescent in both sexes ....*Notogonia*

9. A more or less distinct swelling or fold along the inner eye margins; posterior ocelli placed obliquely, elongate and curved posteriorly; pygidium of ♀ well defined, its apical portion rather sparsely pubescent; insects never densely pilose ...... *Larropsis*

   No swelling along the inner eye margins; pygidium of ♂ and ♀ entirely naked to densely clothed with pubescence 10

10. Posterior ocelli very elongate, anteriorly almost longitudinal in position, their posterior end curved into a hook or flat spiral pygidium covered with bristles or pubescence (usually metallic), that of ♀ always well defined; fore tarsal comb of ♂ composed of short spines; insects often bee-like .... *Tachytes*

    Posterior ocelli reniform or oblong; pygidium of ♀ usually well defined and naked; fore tarsal comb of ♀ with long flexible spines; insects never densely pubescent nor bee-like, *Tachysphex*

The genus *Miscophinus*, which is inserted in the above key, has not as yet been reported from Kansas, though it is probable that it occurs in the state.

Order of treatment: *Larra, Notogonia, Larropsis, Tachytes, Tachysphex, Lyroda, Plenoculus, Niteliopsis, Miscophus,* and *Bothynostethus.*

LARRA Fab.

Fab.; Ent. Syst. t. II, p. 220; 1793.
Syn. *Larrada* Sm. 1856.

Form rather stout, sparsely pubescent. Head wider than thorax, with a longitudinal fold along the inner eye margin, and somewhat angulate and depressed above; antennæ rather stout, usually in a distinctly elbowed position, each rather long scape fitting into a longitudinal facial impression; anterior ocellus small and round, in a depression which forms an obtuse angle with the rest of the face; posterior ocelli indistinct, oval and transverse, situated on the posterior edge of a transverse fold from eye to eye; mandibles emarginate beneath, in our species indistinctly dentate within. Thorax long; pronotum not angled into the mesonotum, and not or very slightly depressed below the level of the latter; propodeum long, truncate posteriorly; marginal cell of the fore wings truncate and with an evident appendiculation; legs stout and spinose. Abdomen slightly depressed.

♀. Pygidium well defined, shining, naked except for a very few hairs along the marginal furrow; comb of fore tarsi not well defined.

♂. More pilose than the ♀; pygidial area margined; fore femora entire beneath at the base; eighth ventral segment with a shallow emargination.

Larra analis Fab.

(Fig. 16, wings; 24, mandible; 107, pygidium, ♀.)

Larra analis Fab.; Syst. Piez., 1804, p. 220. ♀.
Larra analis Fox; Proc. Acad. Nat. Sci. Phil., 481-482; 1893. ♀.

A large deep black species, with the apical portion of the abdomen bright red. The ♂ of this species is more pilose, has the abdomen entirely black and the pygidial area pilose.

From Cheyenne and Douglas counties. Rare.

NOTOGONIA Costa.

Costa; Ann. Mus. Zoöl. Univ. Napoli (Ann. IV), p. 80 *et* 82; 1867.
Syn. *Larrada* Sm. 1856.
Larra Patt. 1880.

Form rather slender to stout. Head slightly wider than thorax, the facial folds and depressions much as in *Larra;* antennæ comparatively slender, the scape rather long; ocelli bordering on a low swelling, posterior ocelli small, oval, flattened and transverse; mandibles emarginate beneath, with two more or less distinct teeth within. Thorax rather long; pronotum angled into the mesonotum and somewhat depressed below the level of the latter; propodeum long and truncate posteriorly; marginal cell of fore wings truncate, the appendiculation fairly distinct; legs elongate, spinose. Pygidial area pilose.

♀. Comb of fore tarsi hardly differentiated, with only a few spines; pygidial area with well-defined sides, rounded triangular, and pubescent except at extreme base.

♂. Fore femora entire beneath at base; pygidial area not well defined, finely though not densely pubescent throughout; eighth ventral segment rounded.

This genus is close to *Larra,* and, like it, is poorly represented in the United States.

Notogonia argentata (Bve.).

(Fig. 34, ocellar area; 49, thorax; 88, antennal cleaner; 80, fore tarsus; 97, pygidium, ♀.)

Larra argentata (Bve.); Ins. Afr. at Amer., p. 119, taf. III, f. 9; 1805.
Notogonia argentata Fox; Proc. Acad. Nat. Sci. Phil., 485-486; 1883. ♂ ♀.

An easily recognized steel gray species, with subhyaline wings and long legs. Barton, Russell, Phillips and Douglas counties; June-September. More common in eastern Kansas.

LARROPSIS Patt.

Patton; Ent. News, III, 90; 1892.
Syn. *Ancistromma* Fox; Proc. Acad. Nat. Sci. Phil., 487; 1893.

Form moderately stout, naked or sparsely pubescent. Head usually short, regularly rounded, distinctly wider than thorax; antennæ usually longer than in either *Tachytes* or *Tachysphex,* the scape being comparatively shorter and stouter than in the above genera; head in front distinctly raised along the inner eye margin; ocelli bordering a swelling which is less distinct and more weakly furrowed than in *Tachytes* or *Tachysphex;* fore ocellus round, the posterior pair flattened, elongate and hooked posteriorly, shorter and more obliquely arranged than in *Tachytes;* mandibles emarginate beneath, with two teeth interiorly. Thorax

moderate; propodeum somewhat truncate posteriorly; marginal cell more or less truncate, with an appendiculation. Pygidial area at least partly pilose.

♀. Comb of fore tarsi of stout thorns, perhaps a little longer than in *Tachytes;* pygidial area with the borders well defined, covered with sparse pubescence for its apical half or two-thirds.

♂. Fore femora emarginate near the base beneath, the inner border of this emargination forming a distinct tooth, more acute than in the other genera having this emargination; pygidial area without raised borders, sparsely pubescent; eighth ventral segment of the abdomen rounded out, in a few species very shallowly emarginate.

This genus is represented in our state by twelve species. These insects are seldom seen. They are sometimes taken about the burrows of animals.

KEY TO THE SPECIES OF LARROPSIS.

Females.

1. Interocular space at vertex less than or about equal to the length of antennal joints 2 and 3 united, and about equal to one-third the interocular space at the base of the clypeus.............. 2
   Interocular space at vertex distinctly wider than the length of antennal joints 2 and 3, and two-thirds to three-fourths the interocular space at the base of the clypeus.................. 3
2. Disc of propodeum with delicate striæ which diverge from beyond the base; wings nearly clear........................*distincta*
   Disc of propodeum granulate or with very indistinctly diverging striæ; wings smoky ....*aurantia*
3. Antennæ long and setaceous, longer than head and thorax (except in *divisa,* where they are about equal to head and thorax); fourth antennal joint three to four times as long as its middle diameter 4
   Antennæ shorter and stouter, shorter than head and thorax; fourth antennal joint about two times as long as its middle diameter.. 6
4. Pygidium well polished, sparsely large punctate, almost naked; form slender; abdomen black and red; wings light smoky....*conferta*
   Pygidium rough, rather densely punctate, pubescent; form stouter, with dark, fuscous wings 5
5. Antennæ longer than head and thorax; second abdominal segment reddish; tarsi black or nearly so......................*rugosa*
   Antennæ about as long as head and thorax; abdomen varying from red and black to red; tarsi testaceous.................*divisa*
6. Wings smoky; insect black; ocellar space very closely punctate ....*vegetoides*
   Wings pale yellowish hyaline; most of the thorax, and the abdomen entirely, pale brownish red; ocellar space rather sparsely punctate ....*chilopsidis*

Males.

1. Interocular space at vertex not wider than length of antennal joints 2 and 3; wings clear 2
   Interocular space at vertex decidedly wider than the length of antennal joints 2 and 3; wings clear to fuscous 3
2. Disc of propodeum with delicate striæ, which diverge from beyond the base; third antennal joint one-third shorter than 4. .*distincta*
   Disc of propodeum finely granulate; antennal joints 3 and 4 subequal .... *aurentia*
3. Wings clear or nearly so 4
   Wings fuscous 8
4. Abdomen entirely, legs and venation largely, dull yellowish brown; length, 8 mm. .... *tachysphecoides*
   Abdomen not entirely red or yellowish brown; venation dark brown or black 5
5. Second submarginal cell almost triangular, the first transverse cubitus therefore very close to the second on the radius; first recurrent almost interstitial with the first transverse cubitus; a rather distinct sulcation from the anterior ocellus forward; abdomen black .... *pænerugosa*
   Venation normal, not as above; sulcation from anterior ocellus indistinct or wanting 6
6. Abdomen red and black, rarely entirely red .... *conferta*
   Abdomen black; punctation a little coarser than in *conferta* 7
7. Disc of propodeum with a longitudinal sulcus only on apical half, and with some rather indistinct raised lines diverging from the base to the sides nearly to its middle length; punctation of scutum rather coarse and so close as to give it an opaque appearance; length, 6 mm. .... *minor*
   Disc of propodeum with a longitudinal sulcus usually extending its entire length, the diverging lines wanting or very short; punctation of scutum rather fine, the punctures well separated; scutum, therefore, rather shining and smooth; length, 8-11 mm. . . *bruneri*
8. Antennæ distinctly shorter than head and thorax together; basal abdominal segments red .... *divisa*
   Antennæ as long as head and thorax, or nearly so; at most the second segment red 9
9. Entirely black; scutum closely but distinctly punctured, therefore shining; abdomen also shining and with indistinct apical fasciæ on segments .... *ater*
   Second abdominal segment red; scutum so closely punctured as to give it a granulate opaque aspect; no sericeous fasciæ on abdomen .... *rugosa*

Larropsis distincta (Smith).

Larra pennsylvanica (?) Bve.
Larrada distincta Smith; Brit. Mus. Cat. Hym., IV, 292. ♀.
Larra distincta Patton; Proc. Bost. Soc. Nat. Hist., XX, 390; 1880. ♂ ♀.
Ancistroma distincta Fox; Proc. Acad. Nat. Sci. Phil., 491-2; 1893. ♂ ♀.

♀. Rather stout; anterior margin of clypeus narrowly emarginate mesad, bidentate laterally, though not strongly; antennæ somewhat shorter than head and thorax, not stout, joint 3 shorter than 4; vertex with fine, close punctures, which are more separate on scutum; disc of propodeum with diverging striæ, posterior face with transverse striæ and a strong sulcus; tarsal comb not strong; longer spur of hind tibiæ nearly as long as the first joint of the hind tarsi. Abdomen finely punctate; pygidium long and narrow, deep punctate, rather blunt apically. *Black;* tarsi dull brownish, wings nearly clear, venation brown, abdomen with the apical margins of segments 1 and 2 particularly with indications of red. Scarcely pubescent; pygidial bristles brownish. Length, 11-13 mm.

♂. Anterior margin of clypeus emarginate mesad, indistinctly bidentate laterally; sculpture about as in ♀. Abdomen black or red and black. More pubescent than in ♀. Length, 8-12 mm.

Three ♂ ♂ from Norton county; Aug. 24 to Sept. 4, 1912. The ♀ ♀ are eastern examples.

Larropsis aurantia (Fox).

(Fig. 36, ocellar area.)

Larra aurantia Fox; Ent. News, II, 194; 1891. ♀.
Ancistromma aurantia Fox; Proc. Acad. Nat. Sci. Phil., 490; 1893. ♂ ♀.

♀. Stout. Anterior margin of clypeus subtruncate, a little notched mesad, the lateral angle drawn out into a large pointed tooth, a small tooth just inside the same; antennæ long, slender and acuminate, joints 3 and 4 subequal; front, vertex and scutum very finely and closely punctate, a little more separately on scutellum; disc of propodeum rugose-granulate, sometimes with indications of diverging striæ, a median impressed line; posterior face coarsely transverse-striate, with a median furrow; legs rather strongly spinose; abdomen shining; pygidium rather sparsely punctate. *Black;* tarsi largely dull reddish brown; wings fuscous, venation blackish; abdomen orange. Short sparse pubescence on tibiæ and tarsi; pile on pygidium pale yellowish brown. Length, 11-15 mm.

♂. Anterior margin of clypeus more narrowly rounded out, emarginate mesad, a stout tooth laterally; the clypeus sparsely coarse-punctate; punctation of head somewhat coarser than in ♀, that of scutum about as in that sex; legs rather feebly spinose; wings clearer than in ♀, subhyaline; apical abdominal segments black; head, thorax and abdomen with silvery pile, which is rather sparse except on face; pygidial pubescence yellowish brown. Length 10-11 mm.

Four ♀ ♀ and 1 ♂; Norton, Phillips, Thomas and Lane counties; July 3 to Aug. 24, 1910-'12.

Larropsis conferta (Fox).

Ancistromma conferta Fox; Proc. Acad. Nat. Sci. Phil., 494-5; 1893. ♂ ♀.

♀. Rather slender. Anterior margin of clypeus broadly rounded out, indistinctly dentate laterally; joint 3 of antennæ one-third to one-fourth shorter than 4, the interocular space at vertex very little less than antennal joints 3 and 4; head and scutum finely and distinctly punctate; disc of propodeum with a median furrow (widened apically) and rather fine transverse striæ; posterior face finely granulate-striate, with a median sulcus; legs slender, moderately spinose; pygidial area shining, sparsely punctate and hairy. *Black;* tibiæ and tarsi more or less brownish, wings fusco-hyaline, yellowish in age, venation dark; basal abdominal segments and usually apex of pygidium reddish. Insect with sparse sericeous pile. Length, 10-15 mm.

♂. Antennæ stouter and sculpture coarser than in ♀; colored as in that sex, but slightly more pilose. Length, 8-11 mm.

Seven ♀ ♀ and two ♂ ♂; western Kansas.

Larropsis bruneri (Smith).

(Fig. 101, eighth ventral plate of ♂.)

Ancistromma bruneri Smith, H. S.; Ent. News, XVI, 249; 1906. ♂.

♂. In form like *conferta*. Anterior margin of clypeus strongly rounded out; front and vertex not quite as closely punctate as in *conferta;* joint 3 of antennæ a little shorter than 4, the interocular space almost equal to joints 2-4; thorax with fine separate punctures; disc of propodeum rather coarsely granulate-striate mesad (elsewhere simply granulate) where it is depressed, and often distinctly carinate, sides granulate, posterior face granulate-striate, and with a deep dorsally widened sulcus; wings almost clear. *Black;* apex of tarsi reddish. Sparsely pilose and fasciate. Length, 7-11 mm.

A fair series from the western part of the state. They were compared with a paratype from Nebraska.

Larropsis pænerugosa (Vier.).

(Fig. 46, tip of fore wing.)

Ancistromma pænerugosa Viereck; Trans. Am. Ent. Soc., XXXII, 210; 1906. ♂.

♂. Very like *bruneri*, from which it may be distinguished by the somewhat broader interocular space at vertex, the more distinct median impression before the ocellar space, and by the fact that the first and second transverse-cubitus veins are very proximate on the radius, and the first transverse-cubitus and first recurrent veins are nearly or quite interstitial. *Black;* wings clear; colored and ornamented as in *bruneri*. Length, 8 mm. (type).

One ♂, University of Kansas. Collected in Clark county, Kansas; June; F. H. Snow.

Larropsis minor n. sp.

♂. Somewhat slender. Anterior margin of clypeus rounded out, not dentate laterally, strongly and closely punctate; antennæ rather stout, almost as long as head and thorax; joint 3 somewhat shorter than 4, the interocular space at vertex about equal to joints 2-4; front and vertex very closely punctate, the punctures not very fine, however; scutum and scutellum rather coarsely and very closely punctate, giving these regions a granulate aspect; pleuræ about as dorsum; disc of propodeum granulate, with an apical sulcus; indications of transverse striæ and basal striæ, which diverge to about the middle length, sides and posterior face granulate, the latter with a large fovea near the top; legs weakly spinose; venation normal; abdomen finely punctate; pygidial area with large, separate punctures; eighth ventral segment rounded. *Black;* fore femora at base, tibiæ slightly, and tarsi in part, ferruginous; venation dark brown. Face in part, pleuræ and sternum in part, and the abdomen with pale pile; the abdomen rather indistinctly pale sericeous-fasciate. Length, 6 mm. (type).

One ♂, Seward county, Kansas, August 18, 1911.

Related to *bruneri* and *pænerugosa,* from which it differs in being much smaller, in having generally coarser and closer punctures, etc.

Larropsis divisa (Patton).

(Fig. 99, pygidium ♀.)

Larra divisa Patton; Bull. U. S. Geol. Surv., V, 368; 1879. ♀.
Ancistromma divisa Fox; Proc. Acad. Nat. Sci. Phil., 495; 1893. ♂ ♀.

♀. Stout. Anterior margin of clypeus broadly rounded out, bidentate laterally; antennæ long and slender, joint 3 a little longer than 4; front rather coarsely but closely punctate; scutum compactly punctate; disc of propodeum sulcate mesad and there rather coarsely transverse-striate, posterior face granulate-striate and with a median impressed line; legs tolerably spinose; pygidial area of the usual form, well punctate. *Black;* tarsi in part brownish red, wings dark fuscous. venation brown to dark brown; first segment of abdomen largely black, the rest orange red or the abdomen all red. Pubescence of pygidium light yellowish brown. Length, 14-16 mm.

♂. Anterior margin of clypeus not dentate laterally; antennæ shorter than in ♀, distinctly shorter than head and thorax; sculpture generally coarser; metathorax transversely rugose. First three abdominal segments red. Sparse silvery pile. Length, 12-13 mm.

Eleven ♀ ♀; from Wallace, Stanton, Seward, Stevens and Morton counties; July 30 to August 18, 1910-'11.

Larropsis ater n. sp.

(Fig. 100, ventral plate of ♂.)

♂. Medium stout. Anterior margin of clypeus rounded out, not dentate laterally, strongly punctate, much more sparsely and coarsely so distally; antennæ rather stout, nearly as long as head and thorax together, joint 3 somewhat shorter than 4, the interocular space at vertex about equal to joints 2-4; front and vertex finely punctate, in

fact almost granulate, punctures sparser on anterior part of vertex and in the vicinity of the anterior ocellus; scutum and scutellum closely punctate, the punctures not very fine but distinct; pleuræ closely punctate; disc of propodeum with some irregular median transverse striæ and a shallow median depression which is stronger and widened apically; the rest of the disc is granulate, sides of propodeum finely granulate, the posterior face granulate-striate, a narrow median sulcus near the top of the posterior face and a raised line near the bottom (pedicel of abdomen); legs moderately spinose; venation normal; abdomen finely punctate, the pygidium coarsely so, eighth ventral segment rounded out. *Black;* apex of tarsi somewhat testaceous, as also a part of tegulæ; wings dark fuscous, venation still darker. Sparse erect brownish pile on upper portion of frons and on the vertex and sides of propodeum; abdomen with weak dorso-lateral silvery fasciæ of pile; pygidium sparsely pubescent. Length, 11.5 mm. (type); range, 8.5-11.5 mm.

Twenty-three specimens from Meade, Morton, Wallace, Norton, Grant, Stanton and Seward counties. There are also specimens from Montana, etc., in the Philadelphia Academy of Sciences.

This insect has been regarded by Fox as a black variety of *rugosa*, from which it differs constantly in a large series of both species. *Ater* has the scutum shining and less punctate, as opposed to the almost opaque and granulate scutum of *rugosa*. It also averages smaller than *rugosa* and the antennæ appear a little stouter; the median impressed line of the disc of the propodeum is not polished apically, as is somewhat the case with *rugosa*, while the abdomen is weakly fasciate in the new species. It is related to *rugosa* and *tenuicornis*.

Larropsis rugosa (Fox).

Ancistromma rugosa Fox; Proc. Acad. Nat. Sci. Phil., 496-7; 1893. ♂.

♀. Moderately slender. Anterior margin of clypeus broadly rounded out, with two rather obtuse lateral teeth; mandibles slender, bidentate within; antennæ long and slender, the apical joints particularly, joints 3 and 4 subequal; front and vertex finely and closely punctuate, appearing almost granulate; pronotum and mesonotum punctate about like head; disc of propodeum finely granulate, but with rather irregular transverse striæ on the shining, rather broad and slightly depressed median line which widens apically; the narrow sulcus on the posterior face widens dorsally; the face itself is finely granulate; legs rather delicately spinose; the tarsal comb of weak, slender spines; longer metatibial spur shorter than first joint of hind tarsi; abdomen finely and closely punctate; pygidium rather narrow, its sides very slightly bowed out, rather broadly rounded apically and somewhat closely punctate and armed with short bristles for its apical two-thirds or more. *Black;* mandibles dark red in the middle; tip of tegulæ brownish; tarsi somewhat brownish; wings dark fuscous iridescent; second abdominal segment orange red; pygidial bristles brownish. Practically devoid of pubescence or pile. Length, 16 mm.

♂. Anterior margin of clypeus more narrowly rounded in this sex, not dentate; antennæ stouter; sculpture somewhat coarser; the disc of the propodeum more distinctly furrowed; pygidium less pilose. Colored like the ♀.

One ♀, Norton county; eleven ♂ ♂, Wallace, Morton and Wichita counties; August 5-24. There is also a ♀ (this sex I do not find described) in the collection of the Philadelphia Academy of Sciences. The species is easily recognized by the orange-red band on the abdomen and by the opaque notum.

Larropsis vegetoides (Vier.)

Ancistromma vegetoides Viereck; Trans. Am. Ent. Soc., XXXII, 208; 1906. ♀.

♀. Very like *vegeta*. Of moderate build. Clypeus rounded out anteriorly, sparsely coarse punctate, two obscure lateral teeth; antennæ not long, of fairly uniform thickness, joints 3 and 4 subequal; interocular space at vertex about equal to antennal joints 2-4; front and vertex very finely punctate; scutum and scutellum appearing granulate, the sides finely granulate-punctate; disc of propodeum rather indistinctly and finely transverse-striate; a median sulcus, which is quite deep; posterior face finely granulate-striate, the median sulcus deep; legs well spined, the fossorial comb well developed; abdomen hardly punctate above, a few large punctures below; pygidium smooth, with some large separate punctures, its sides somewhat arcuate. *Black;* tarsi becoming brown apically; wings rather dark fuscous; apex of pygidium brownish. Insect covered with very short, inconspicuous pile; pygidium with sparse bristles on apical half. Length, 12 mm.

Two ♀ ♀, Clark county, Kansas; June; F. H. Snow. One of these specimens is the type.

Larropsis tachysphecoides (Vier.)

Ancistromma tachysphecoides Viereck; Trans. Am. Ent. Soc., XXXII, 209-10; 1906. ♂.

"Belongs near *chilopsidis*, from which it is very different."—Vier.

♂. Somewhat slender. Anterior margin of clypeus rounded out, no teeth laterally; antennæ not slender, of rather uniform thickness, third joint about one-quarter shorter than fourth; interocular space at vertex only a little less than at clypeus and greater than length of antennal joints 2-4; punctures well separated on the middle of front and vertex, more closely punctate laterally; scutum and scutellum with rather large separate punctures, the mesopleuræ with large shallow ones; disc of propodeum transversely striate at the median furrow posterior face granulate, with a wide and deep fovea near the top, the sides rather finely rugose-striate; legs moderately spinose; third submarginal cell of fore wings wider than the second along the radius; last dorsal segment of abodmen with shallow punctures, the eighth ventral slightly emarginate mesad. *Black;* tegulæ and venation testaceous; legs, except coxæ, trochanters, and a part of the middle femora, and the abdomen brownish testaceous. Very slightly pubescent. Length, 8 mm. (type).

Clark county, Kansas; F. H. Snow. There is also a ♂ in the U. S. N. Museum from Mesilla Park (New Mex.).

This may eventually prove to be the ♂ of *chilopsidis*, which, besides having the same habitat, it resembles a good deal.

Larropsis chilopsidis (Ckll. & Fox).

Ancistromma chilopsidis Ckll. & Fox; P. Ac. Philad., 137; 1897. ♀.
Ancistromma zerbeii Viereck; Trans. Am. Ent. Soc., XXXII, 208-9; 1906. ♀.

♀. Anterior margin of clypeus rounded out, slightly and narrowly emarginate mesad, obtusely bidentate laterally, with large sparse punctures; front and vertex with well-separated and moderately small punctures; antennæ not long, of nearly uniform thickness, joint 3 very slightly longer than 4; interocular space at vertex more than the length of antennal joints 2-4; prothorax and mesothorax very finely and closely punctate, nearly granular; mesopleuræ closely punctate; disc of propodeum with very fine striæ, which are transverse in the middle and more or less diverging at the base and apex; the propodeum hardly sulcate except at base and apex, the posterior face with a sulcation, this face and the sides indistinctly fine striate; legs strongly spinose, the fossorial comb of quite long bristles; abdomen shining, a few punctations ventrad; pygidial area polished, rather broad, the sides bowed out, quite sparsely punctate and pilose at apex. "*Testaceo-castaneus;* head black excepting the greater part of the clypeus, mandibles and antennæ, which are castaneous" (Vier., for *zerbeii*); antennæ darker apically; sternum of thorax largely black, also a portion of the base of coxæ; wings yellowish hyaline, venation yellowish. Pronotum and mesonotum with considerable short, pale, brownish pile; pygidium with a few pale reddish-brown hairs at apex. Length, 10-12 mm.

Five ♀♀, Clark county, Kansas; F. H. Snow. One of the above specimens has the thorax nearly all black and the apical half of the antennæ nearly black.

While at the Philadelphia Academy of Sciences last winter, the writer noticed the resemblance of *zerbeii* Vier. to *chilopsidis* Ckll. & Fox. Not having the first species with me to compare, notes were taken on the type *chilopsidis*. These were found to fit *zerbeii* well, and a specimen of the latter sent to Mr. Fox, at Philadelphia, to compare with *chilopsidis* proved in his opinion to be the same as *chilopsidis*. The insect is allied to *vegetoides*, notwithstanding the difference in color, etc., between the two.

TACHYTES Panzer.

Panzer; Krit. Rev., II, p. 129; 1806.
Syn. *Lyrops* Illig.; 1807.

Form stout to rather elongate, more or less pubescent, sometimes beelike. Head as wide as to slightly wider than thorax; antennæ usually rather stout; ocelli bordering on a swelling which is more or less furrowed longitudinally, the posterior pair very elongate, flattened and hooked posteriorly, their anterior portion almost longitudinal in position; mandibles emarginate beneath, with one or two teeth within; propodeum

rounded posteriorly; marginal cell obtuse at apex, the appendiculation rather indistinct; legs stout, spinose; abdomen often depressed; pygidial area always with appressed pile or bristles, which are usually metallic in color.

♂. Comb of fore tarsi composed of stout thorns; pygidial area well defined by carinate borders.

♀. Fore femora simple or emarginate beneath; fore coxæ with or without an elongate process; pygidium with or without carinate borders; its pubescence, in all the species which I have seen, is silvery; eighth ventral segment emarginate.

This genus, which Fox divides into two sections, is well represented in our state. These are perhaps the most commonly seen of our larrids.

Key to the Species of Tachytes.

Females.

1. Anterior margin of clypeus produced in the middle into a rather *narrow* lobe (figs. 52 and 56); lateral margins of clypeus distinctly dentate; legs (femora and tibiæ) largely ferruginous.. 2
   Anterior margin of clypeus not produced into a lobe, though most frequently rounded out, sometimes slightly emarginate mesad and usually dentate laterally; legs (except in the large, yellowish-winged species *distinctus*) black..................... 3
2. Pygidium scarce constricted preapically, covered with fine golden pile .... *validus*
   Pygidium somewhat constricted before apex (fig. 90), its bristles bronzy ....*mandibularis*
3. Clypeus armed with a large prong on either side (fig. 61); pygidium triangular (fig. 93), with rather sparse, stout, appressed bristles, which are pale golden or silvery..............*mergus*
   Clypeus without a lateral prong; pygidium well covered with pile or fine bristles (figs. 91 and 92).......................... 4
4. Clypeus rounded out, armed laterally with more or less distinct teeth; abdomen black or black and ferruginous............... 5
   Clypeus without teeth (fig. 54), its anterior margin subtruncate, with a slight production mesad; abdomen black with brassy or silvery fasciæ; wings light fuscous.................*obductus*
5. Metatibiæ with at least the basal half of the outer posterior row of spines short, blunt and thorn-like, the row much stouter than those on the first joint of the hind tarsi, and usually extending to quite near the base of the tibiæ (fig. 82); pygidium (at least in fresh specimens) with some erect hair in addition to the fine appressed pile; species rather small........................ 6
   Metatibiæ with the spines not short as in the above, usually well pointed and differing but little from those of the first joint of the hind tarsi, and usually ending (or beginning) at a good distance before the base of the tibiæ; no erect hair on pygidium, the latter golden or bronzy.............................. 7

6. Mandibles very narrowly notched exteriorly (fig. 25); black species .... *obscurus*
   Mandibles with the notch normal; the first two or three segments of the abdomen ferruginous .... *abdominalis*
7. Abdomen in part red 8
   Abdomen entirely black 9
8. Clypeus not or very slightly emarginate mesad; pygidium not at all constricted near the apex, bronzy; species with considerable erect pile on head and thorax........ *fulviventris*
   Clypeus shallowly emarginate mesad (fig. 53); pygidium a little narrowed before apex; erect pubescence rather sparse. *rufofasciatus*
9. Abdomen with four silvery fasciæ; wings hyaline; legs black.....10
   Abdomen three-fasciate; wings yellowish, dark apically; legs largely ferruginous; pygidium with fine pubescence...*distinctus*
10. Pygidium silvery; spines on legs yellowish white; abdomen greasy-sericeous .... *sericatus*
    Pygidium bronzy; spines on legs brown; abdomen hardly greasy-sericeous .... *pepticus*

Males.

1. Fore coxæ simple; fore femora near the base entire........ 2
   Fore coxæ with an elongate posterior process (fig. 13, *H*); fore femora beneath near the base emarginate (figs. 83 and 85).... 5
2. Joints 9-11 of antennæ visibly broadened on one side (fig. 42), thereby contrasting with the two apical joints; abdomen partly red or entirely black........ *fulviventris*
   Joints 9-11 of antennæ normal, not broadened (figs. 40 and 41).... 3
3. Flagellum with the basal joints distinctly rounded out beneath (fig. 40); thorax with long and rather dense golden pubescence; legs partly ferruginous........ 4
   Flagellum with the basal joints not or very slightly rounded out beneath (fig. 41); the long pubescence of thorax not dense; clypeus broadly rounded out (fig. 59); legs black......*pepticus*
4. Eighth ventral segment rather narrowly emarginate, the lobes broad and rounded........ *validus*
   Eighth ventral segment rather broadly emarginate, the lobes usually narrow and more pointed (fig. 108)......*mandibularis*
5. Pygidium with pile largely suberect; small black species........ 6
   Pygidium with pile all appressed; usually larger species........ 7
6. Silvery fasciæ of abdomen distinct; body well covered with pile; thorax scarcely shining, with larger, coarser punctures..*obscurus*
   Silvery fasciæ of abdomen not very well defined; insect sparsely pilose; thorax shining, the punctures there finer and more separate .... *intermedius*
7. Wings yellow, their apical portion dark, abdomen black; larger species .... *distinctus*
   Wings pale yellowish hyaline, not dark apically; abdominal segments 1 and 2 usually fulvous; rather small species. *rufofasciatus*

T. sericatus is not represented in the collection by a male. This sex resembles *obscurus* a good deal, but the sericeous pubescence is more abundant in *sericatus*.

Tachytes validus Cress.

Tachytes validus Cresson; Trans. Am. Ent. Soc., IV; 1872. ♂ ♀.
Tachytes validus Fox; Trans. Am. Ent. Soc., XIX, 237; 1892. ♂ ♀.

♀. Stout and broad. Clypeus with a quadrate median production, three small lateral teeth; third joint of antennæ longer than fourth; vertex with rather strong separate punctations; scutum very finely punctate; scutellum scarcely impressed; disc of propodeum with a slight impressed line, a subcircular subapical fovea, and a strong median sulcus on posterior face; hind tibiæ with moderately stout spines; abdomen rather broad, depressed; pygidium convex, depressed along the sides of its apical portion. *Black;* legs, except coxæ, trochanters and most of femora, yellow-ferruginous (sometimes this color is more widespread); wings pale yellowish-hyaline, venation ferruginous; pygidium with fine silvery pile. Pubescence of head and thorax pale golden; abdomen with four silvery fasciæ. Length, 18-22 mm.

♂. More slender as a rule than ♀. Joints 1-5 of flagellum strongly rounded out beneath; scutellum with a distinct median impressed line; eighth ventral plate rather narrowly emarginate. Length, 15-19 mm.

One ♀, labeled "Kans.," identified by E. T. Cresson, December, 1878. The abdomen is lacking in this specimen.

Tachytes mandibularis Patt.

(Fig. 40, antenna; 52, clypeus; 90, pygidium, ♀; 108, eighth ventral segment, ♀.)

Tachytes mandibularis Patton; Proc. Bost. Soc. Nat. Hist., XX, 394; 1880. ♂ ♀.
Tachytes mandibularis Fox; Trans. Am. Ent. Soc., XIX, 237-238; 1892. ♂ ♀.

♀. Stout. Clypeus with the median process narrower than in *validus,* three distinct lateral teeth; third joint of antennæ somewhat longer than fourth; vertex finely and closely punctate; scutum likewise; scutellum scarcely impressed; disc of propodeum with a wide median sulcus or furrow, a subtriangular fovea before apex, posterior face with a strong median furrow; spines on posterior tibiæ rather slender; abdomen broad, somewhat depressed; pygidium subpyriform, somewhat narrowed before apex, the short bristles not concealing the disc. *Black;* basal half of mandibles, scape beneath, apex of femora, tibiæ and tarsi, ferruginous; wings pale yellowish hyaline, venation pale brown; pygidial area with bronzy bristles. Pubescence dense, rather dull golden; abdomen with four silvery fasciæ. Length, 14-17 mm.

♂. Anterior margin of clypeus drawn out mesad, a large distinct lateral tooth; joints 1-5 of antennæ rounded out beneath; hind tarsi not spinose; eighth ventral segment rather broadly emarginate. Length, 12-14 mm.

Douglas, Pratt, Kiowa, Russell, Rawlins, Osborne and Rooks counties; June-August.

A rather uncommon species in our state. The western Kansas examples are rather large, and agree in some respects with *propinquus* Roh.

Tachytes obductus Fox.

(Fig. 54, clypeus, ♀; 91, pygidium, ♀.)

Tachytes obductus Fox; Trans. Am. Ent. Soc., XIX, 250; 1892. ♀.

♀. Moderately stout. Anterior margin of clypeus produced into a moderately broad subtruncation, which itself is slightly produced mesad; frons and vertex rather finely and closely punctate; joints 3 and 4 of antennæ subequal; scutum punctate about like vertex; scutellum not impressed; disc of propodeum very finely granulate-reticulate, the sides more shining and very finely punctate, the median impressed line broad and indistinct, obscurely transversely striate and terminating in a strong, rather pyriform subapical fovea, posterior face with an impressed line; legs not very spinose, metatibial spines moderately stout, fore tarsal comb short; pygidium with the sides nearly straight (much as in *obscurus*). *Black;* spines of legs brown to black, wings light fuscous; pygidium with fine bright golden pile. Pubescence yellowish white or pale yellow; abdomen with segments 1-5 brassy fasciate or with silvery fasciæ. Length, 10.5 mm.

Four ♀♀; Osborne county, Kansas, August 3, 1912. It appears to be a rather rare insect. The ♂ does not seem to have been described.

Tachytes abdominalis (Say).

(Fig. 55, clypeus, ♀; 82, metatibia.)

Larra abdominalis Say; West. Quar. Rep., II, 77; 1823. ♀.
Tachytes abdominalis Fox; Trans. Am. Ent. Soc., XIX, 248-9; 1892. ♀.

♀. Rather elongate. Clypeus rounded out, very slightly and narrowly emarginate mesad, two lateral teeth; third antennal joint not longer than fourth; vertex with fine, close punctations; scutum with more separate punctations; scutellum not impresed; disc of propodeum with or without a slight impressed line, the subapical fovea rather shallow, posterior face with a rather narrow sulcus; metatibial spines stout, the more basal one blunt and thorn-like; the two recurrent veins usually quite proximate on the cubitus; abdomen rather long, pygidium rather broadly rounded apically, its pile dense and diverging. *Black;* apex of tarsi more or less reddish; wings subhyaline; abdominal segments 1 and 2 or 1 to 3 ferruginous; pygidium as a rule silvery golden basally, becoming bronzy to darker apically. Pubescence of head, thorax and legs pale golden to nearly silvery; abdomen with four pale golden fasciæ. Length, 9-13 mm.

A good series from western Kansas. The ♂ has not as yet been found or recognized.

Tachytes intermedius (Vier.)

Tachysphex intermedius Viereck; Trans. Am. Ent. Soc., XXXII, 211-12; 1906. ♂.

♂. Slender. Clypeus well produced and rounded, not dentate laterally; third joint of antennæ a little shorter than fourth; vertex with fine separate punctations, as also scutum, which is shining; scutellum not impressed; disc of propodeum finely granulate, without an impressed line, apical fovea shallow and rather indistinct, a strong sulcus on posterior face; abdomen smooth and slender, eighth ventral segment rather broadly emarginate. *Black;* marked like *obscurus;* wings hyaline, venation testaceous. Pubescence sparser than in *obscurus;* that of head, thorax and abdomen white or silvery; suberect pile on pygidium; that of legs with a golden tint. Length, 8.25 mm. (type).

One ♂; Douglas county, Kansas; F. H. Snow.

This is not a *Tachysphex,* as first described, and is therefore not related to *Tachysphex punctifrons* or *æthiops,* as stated by its describer, but is close to *obscurus;* the clypeus is more produced than in that species, however, the punctation more delicate, the thorax and abdomen more polished, and the pubescence sparser.

Tachytes obscurus Cress.

(Fig. 25, mandible, ♀; 58 clypeus, ♂.)

Tachytes obscurus Fox; Trans. Am. Ent. Soc., XIX, 249; 1892. ♂ ♀.
Tachytes texanus Cresson; Trans. Am. Ent. Soc., IV, 217; 1872. ♂.
Tachytes obscurus Fox; Trans. Am. Ent., XIX, 249; 1892. ♂ ♀.

♀. Rather slender. Clypeus rounded out, two blunt lateral teeth; joints 3 and 4 of antennæ subequal; mandibles broad with a very narrow exterior notch; vertex and scutum with fine separate punctations; scutellum not impressed; disc of propodeum very finely granulate, and with sparse shallow punctures, subapical fovea distinct, as is also the sulcus on the posterior face; metatibial spines quite stout and thorn-like, stouter than the same in *abdominalis;* abdomen rather long, somewhat depressed, pygidium nearly straight, much like that of *abdominalis,* covered with fine appressed pile and sparse erect hair. *Black;* wings subhyaline; pygidium with the pile somewhat silvery at base, bronzy apically. Pubescence of head and thorax silvery; abdomen with four silvery fasciæ. Length, 13-14 mm.

♂. Mandibles normally notched; spines on posterior tibiæ not stout as in ♀; eighth ventral segment of abdomen broadly emarginate. Length, 9-11 mm.

Four ♀ ♀ and numerous ♂ ♂ from western Kansas, besides a few from Douglas county, in the eastern part of the state. I have found the ♀ to be very rare.

Tachytes rufofasciatus Cress.

(Fig. 53, clypeus, ♀.)

Tachytes, rufo-fasciata Cresson; Trans. Am. Ent. Soc., IV, 217-18; 1872. ♂.

Tachytes rufofasciatus Fox; Trans. Am. Ent. Soc., XIX, 247-8; 1892. ♂ ♀.

♀. Rather slender to moderately stout. Clypeus rounded out anteriorly, a little emarginate mesad and bidentate laterally; joint 3 of antennæ longer than 4 (subequal in some slender specimens); vertex and thorax finely and closely punctate; scutellum not impressed; disc of propodeum with shallow, indistinct punctures, subapical fovea rather shallow, the sulcus on the posterior face deep; spines on posterior tibiæ not stout; abdomen sometimes rather long; pygidium a little constricted before the apex, the pile fine and dense. *Black;* wings nearly clear; apical portion of legs more or less reddish, spines pale; abdomen varying from entirely to scarcely at all ferruginous, the ferruginous commencing from the base as in *fulviventris;* pygidium bright golden. Pubescence of head and thorax whitish or nearly so, the erect hair sparce; abdominal fasciæ golden. Length, 11-15 mm.

♂. Clypeus rather narrowly produced; eighth ventral segment broadly emarginate; apex of trochanters, all the tibiæ and tarsi ferruginous; apex of segments 1 and 2 of abdomen ferruginous or testaceous. Length, 11-15 mm.

The identification of these few Kansas specimens is somewhat doubtful. One, a ♀, is quite small, and here the clypeus is not emarginate as in the larger specimens. This small one is from Morton county; the others, which are stouter as well as larger, were taken in the northern part of the state. The ♂ ♂ hail from Texas.

Tachytes fulviventris Cress.

(Fig. 53A, clypeus. ♂; 42, antenna, ♂.)

Tachytes fulviventris Cresson; Proc. Ent. Soc. Phil., IV, 466; 1865: ♀.
Tachytes cælebs Patton; Bull. U. S. Geol. Surv., V, 355. ♂.
Tachytes fulviventris Fox; Trans. Am. Ent. Soc., XIX, 243; 1892. ♀ ♂.

♀. Stout, a little less so than *pepticus.* Clypeus broadly produced anteriorly, the two lateral teeth obscure or prominent; third joint of antennæ longer than fourth; vertex finely punctate, scutum likewise; scutellum not impressed; disc of propodeum without an impressed line, subapical furrow shallow but distinct and transversely striate, a strong sulcus on posterior face; spines on posterior tibiæ moderately stout; abdomen hardly broadened; pygidium convex, the sides nearly straight, covered with fine pile. *Black;* mandibles slightly reddish mesad, last four tarsal joints reddish; wings hyaline, venation pale brown; segments 1-3 of abdomen reddish, pygidial area with black and bronzy pile. Appressed pile pale golden to whitish, the rather dense, erect pubescence pale griseous; abdomen with three silvery fasciæ. Length, 12-17 mm.

♂. Clypeus broadly produced anteriorly and rounded much as in *pepticus;* joints of antennæ 9-11 widened on one side; abdomen red and black or entirely black. Length, 11-14 mm.

Rather common in western Kansas. In the black variety (♂) the antennal joints 9-11 are not always distinctly widened, sometimes making it hard to separate from *pepticus.*

Tachytes pepticus (Say).

(Fig. 59, clypeus, ♂ ♀; 109, eighth ventral plate, ♂.)

Lyrops peptica Say; Bost. Jour. Nat. Hist., I, 371; 1837. ♂ ♀.
Tachyets pepticus Fox; Trans. Am. Ent. Soc., XIX, 242; 1892. ♂ ♀.

♀. Stout. Clypeus broadly produced, slightly emarginate mesad, two lateral teeth; mandibles short and stout; third joint of antennæ longer than fourth; vertex finely and closely punctate, scutum likewise, and depressed anteriorly; scutellum very slightly impressed; disc of propodeum with or without a very faint line, a shallow subapical furrow, a strong median sulcus on posterior face; spines on posterior tibiæ rather blunt; abdomen short, rather broad; pygidium rather narrow, its sides nearly straight. *Black;* tarsi largely ferruginous; wings very slightly fuscous or yellowish, venation brownish. Pubescence of face, collar, between the divisions of the thorax, and legs, silvery; scutum and scutellum with very sparse, dark, erect pubescence, pale on propodeum; abdomen with four silvery fasciæ; pygidium with fine bronzy bristles. Length, 13-16 mm.

♂. Anterior margin of clypeus broadly produced and rounded; joints 3 and 4 of antennæ narrowed basally; subapical fovea of propodeum shining and more distinct than in ♀; emargination of eighth ventral segment broad. Length, 9-11 mm.

Numerous specimens from western Kansas. The ♀ ♀ are decidedly black and rather naked.

Tachytes sericatus Cress.

(Fig. 60, clypeus, ♀.)

Tachytes sericatus Cress; Trans. Am. Ent. Soc., IV, 216; 1872. ♂ ♀.
Tachytes sericatus Fox; Trans. Am. Ent. Soc., XIX, 247; 1892. ♂ ♀.

♀. Rather stout. Anterior margin of clypeus rounded out, a little emarginate mesad, bindentate laterally; antennæ rather short, joints 3 and 4 nearly equal; punctation of head and thorax fine; disc of propodeum with a very indistinct median line, the apical fovea not large; pygidium somewhat triangular, not constricted apically, the sides very little bowed out. *Black;* apical joints of tarsi brownish; wings clear; pygidial pile silvery. Head and thorax with long suberect whitish pubescence; legs with silvery pile and medium stout whitish spines; abdomen four-fasciate, the fine appressed silvery hair giving it a rather greasy appearance. Length, 12-14 mm.

♂. "Form more slender than ♀"; joint 3 of antennæ shorter than 4; eighth ventral segment roundly emarginate. Less silvery than ♀. Length, 10-11 mm.

One ♀; Hamilton county, Kansas; F. H. Snow.

Fox, in his monograph of the genus *Tachytes*, states that the ♀ has a bronzy pygidium, while Cresson in his description of the species states, "apical segment dull silvery." The Kansas specimen agrees with the latter statement.

Tachytes distinctus Sm.

(Pl. XXII and XXIII, external anatomy; fig. 14, wings; 41, antenna ♂; 57, clypeus; 79, 83, 85, legs; 92 and 94, pygidium, ♂ ♀; 111, eighth ventral segment, ♂.)

Tachytes distinctus F. Smith; Cat. Hym. Brit. Mus., IV, 307; 1856. ♀.
Tachytes distinctus Fox; Trans. Am. Ent. Soc., XIX, 246; 1892. ♀.
Tachytes elongatus Fox; Trans. Am. Ent. Soc., XIX, 246; 1892. ♂.

♀. Stout but rather elongate. Clypeus broadly produced, sometimes slightly emarginate mesad, two obtuse lateral teeth; third joint of antennæ longer than fourth; vertex very finely punctate; scutum punctate about like vertex; scutellum not impressed; disc of propodeum with or without a very faint impressed line, a distinct pyriform subapical fovea, a very strong median sulcus on posterior face; metatibial spines stout, not blunt; abdomen long and depressed; pygidium convex, subtriangular, very slightly constricted before apex, its pile short, fine and dense. *Black*; basal portion of mandibles, scape beneath at apex, tegulæ, legs except sometimes basal portion of femora, ferruginous; wings yellowish hyaline, apically darker, venation light brown; pygidial area with long bronzy and blackish pile. Pubescence of head, thorax and legs pale golden; collar sometimes silvery; abdomen with three silvery fasciæ. Length, 15-22 mm.

♂. More slender as a rule than ♀. Anterior margin of clypeus broadly produced; eighth ventral segment of abdomen broadly emarginate; femora largely black; pubescence more griseous than ♀; abdomen four-fasciate. Length, 11-17 mm.

A common and easily determined species; the largest of our larrids. Taken throughout the western half of the state; June-September.

Tachytes mergus Fox.

(Fig. 26, mandible; 61, clypeus, ♀; 93, pygidium, ♀.)

Tachytes mergus Fox; Trans. Am. Ent. Soc., XIX, 250; 1892. ♀.

♀. Somewhat slender. Anterior margin of clypeus with a distinct lateral prong; mandibles decidedly slender; antennæ likewise, the third joint longer than the fourth; vertex and scutum finely punctate; disc of propodeum with a distinct impressed line and a subpyriform subapical fovea, sulcus on posterior face strong; pygidium triangular, with sparse stout bristles. *Black*; at least the apical joints of tarsi reddish; wings clear. Pubescence silvery; bristles of pygidium silvery; to pale golden. Length: 9 mm.

Two ♀♀, from Osborne county, Kansas, August, 1912. A very distinct and apparently rare species.

TACHYSPHEX Kohl.

Kohl; Berl. Ent. Zeitschrift, XXVII, 166, 1883.
Fox; Proc. Acad. Nat. Sci. Phil., 504-5; 1893.
Syn. *Larrada* Sm.
Larra Patton.

Form slender to stout, pubescence short and usually sparse. Head usually distinctly wider than the thorax, face bituberculate behind the antennæ, the latter moderate, usually more slender in the ♀ than in *Tachytes*; ocelli bordering on a longitudinally furrowed swelling, the anterior ocellus round, the posterior pair more or less reniform, flattened and quite obliquely placed; mandibles more strongly emarginate than in *Tachytes;* thorax rather short; propodeum rounded posteriorly; marginal cell of fore wings more or less distinctly truncate; legs rather slender, spinose.

♀. Comb of fore tarsi of long, flexible spines; pygidial area naked and shining, usually with delicate carinate borders.

♂. Fore femora emarginate beneath at base; pygidial area not well defined, with sparse pile; eighth ventral segment well emarginate; sometimes with a median tooth.

This genus is represented in Kansas by twenty-two species. From a systematic standpoint, it is the most difficult group of the family, as many of the species resemble one another very closely. By paying strict attention to the clypeus, pygidium, venation, antennæ and sculpture, the tables should prove helpful.

The length of the pygidial area in the O ♀ seems to have been overestimated by some writers. The author compares the basal width with the length, which is taken to extend from where the lateral carinæ end (toward and not at the base of the segment) to the narrowed tip of the disc. His figures here given will be found to differ, therefore, materially from those of Fox in his monograph of the Larridæ.

KEY TO THE SPECIES OF TACHYSPHEX.

(Use a compound microscope here.)

Females.

1. Interocular space at vertex always distinctly more than one-half the interocular space at the lower edge of the eyes; face with long pile; vertex with long, erect pile, which is at least as long as the diameter of an antennal joint; vertex and thorax always with well-separated punctures, polished. Immediately behind each posterior ocellus is a convexity which resembles a second ocellus, then follows the transverse postocellar impression...

Interocular space at vertex never distinctly as much as one-half the same space at the lower edge of the eyes; vertex glabrous or with very short pile; vertex and thorax often with very fine and close punctures, often subopaque. Immediately behind each posterior ocellus the slope is scarce or not interrupted to the transverse postocellar impression........................

2. Sides of propodeum not striate, or at most with striations only along either edge; dorsum of abdomen, all red.. .....*clarconis*
Sides of propodeum distinctly striate for the entire length; only the tip of the abdomen red.............................. 3

3. Antennæ with longer joints, joint 3 nearly three times the length of its diameter, and about as long as joint 4 (fig. 32, *b*); anterior margin of clypeus with a low blunt tooth or lobe..*fusus*
Antennæ with shorter joints, joint 3 about two times as long as its diameter and distinctly shorter than joint 4 (fig. 32, *a*); anterior margin of clypeus without a median lobe or else very slightly produced mesad........................*terminatus*

4. Anterior margin of clypeus with a prominent *median* tooth (fig. 67); pygidium broad and nearly flat, impunctate or nearly, the bounding carina low, tip broadly rounded (fig. 106)..*dentatus*
Anterior margin of clypeus without a *median* tooth; pygidium usually narrow and more or less punctate.................. 5

5. Abdomen red or red and black............................. 6
Abdomen black 16

6. At least the tibiæ and tarsi reddish, femora more or less red; punctation of thorax very fine and close................... 7
Tibiæ and femora always black, tarsi more or less so; punctation of thorax fine or coarse................................ 8

7. Clypeus rounded out for nearly its entire width, a little elevated on its anterior edge mesad, where it is shallowly emarginate, no lateral teeth (fig. 73); clypeus, sometimes thorax in part, femora and abdomen ferruginous; interocular space at vertex a little wider than the length of antennal joints 2 and 3. *propinquus*
Clypeus distinctly notched mesad on its anterior edge, the two lateral teeth distinct (fig. 66); femora largely, and the apex of abdomen, ferruginous; interocular space at vertex about as wide as the length of antennal joints 2 and 3......*belfragei*

8. Anterior margin of clypeus with a distinct median emargination or incision, and two lateral teeth (fig. 68); upper portion of frons with rather shallow punctures and a finely reticulate surface; pygidium not at all twice as long as wide..*crenuloides*
Anterior margin of clypeus without an emargination or with only a small, shallow one, and with at most one lateral tooth, or without teeth; pygidium longer, from almost two to two and one-half times as long as its basal width.................... 9

9. Sides of propodeum distinctly though not always deeply striate, or striate and punctate combined, shining; scutum frequently with close but separate punctures..........................10
Sides of propodeum finely granular, subopaque; scutum very finely and closely punctate, thereby sometimes appearing granulate..15

10. Disc of propodeum granulate, and in addition has irregular though strong more or less longitudinal striæ extending from one end of the disc to the other; clypeus with one lateral tooth; upper portion of frons with separate punctures, finely reticulate between punctures; abdomen all red................*sculptiloides*
Disc of propodeum coarsely wrinkled; abdomen with only first and second segments red..............................*quebecensis*
Disc of propodeum not as above; wholly or in part red...........11
11. Clypeus entire; medium-sized to rather large species...........12
Clypeus with one lateral tooth (fig. 72); small species, about 6 mm. long..13
12. Abdomen entirely red; the second submarginal cell usually distinctly broader than the third along the radius; truncation of marginal cell only a little oblique and a little less than one-half as long as the distance from the third submarginal (along the radius) to truncation (fig. 47); clypeus not produced mesad; length, 7.5-10 mm.................................*texanus*
Abdomen black apically; second and third submarginal cells usually subequal along the radius; truncation of marginal cell decidedly oblique, and always more than one-half as long as the distance from the third submarginal cell to truncation; anterior margin of clypeus a little produced mesad; length, 7 mm. ....*consimilis?*
13. Abdomen black apically; slender species...........*nigrocaudatus*
Abdomen entirely red.......................................14
14. Form stout; as viewed laterally the abdomen is not or scarcely longer than thorax and propodeum..............*crassiformis*
Form slender; abdomen tapering gradually caudad, distinctly longer than thorax and propodeum...........*plenoculiformis*
15. Abdomen entirely red (clear or obscure); clypeus with one lateral tooth (fig. 62), and sometimes with a shallow emargination mesad; length, 8-11 mm.......................*tarsatus*
Abdomen black apically; clypeus entire; scutum finely granular-punctate, subopaque; length, 7.75 mm............*consimiloides*
16. Wings subfuscous, venation heavy, marginal cell broadly truncate, the third submarginal cell along the radius as broad as the length from the third submarginal cell to truncation (fig. 48); frons very finely granulate, ocellar region (as viewed through a hand lens) opaque; clypeus entire or with an indistinct tooth laterally ....*acuta*
Wings clear or nearly so, venation not heavy, third submarginal cell along the radius seldom as broad as the length from the third submarginal to truncation; ocellar region shining.......17
17. Clypeus broadly though not strongly rounded anteriorly, entire. *sepulcralis*
Clypeus subtruncate anteriorly, produced a little mesad, two lateral teeth (including the rather drawn-out edge of clypeus). *glabrior*

Males.

1. Interocular space at vertex about two-thirds or more the interocular space at the lower edge of the eyes; upper portion of frons and vertex with rather long, sparse, erect pile, which is about as long as the diameter of an antennal joint, head rather sparsely punctate and polished, pseudo-ocelli present (as in ♀ ♀); abdomen red-tipped, rarely entirely black........ 2
   Interocular space at vertex one-half or less (seldom a little more than) the same space at the lower edge of the eyes; no long, erect pile on vertex; no pseudo-ocelli behind the posterior ocelli 3
2. Front with rather fine, close punctures...............*terminatus*
   Front with larger separate punctures...................*fusus*
3. Abdomen red, or red and black.. 4
   Species entirely black 12
4. Sides of propodeum distinctly striate throughout, often punctate between striæ 5
   Sides of propodeum not striate, or striate only at edges, coriaceous, finely granulate or reticulate.......................... 9
5. Anterior margin of clypeus slightly emarginate mesad; disc of propodeum coarsely and irregularly wrinkled; length, 9 mm. *quebecensis*
   Anterior margin of clypeus not emarginate mesad; disc of propodeum not as above.. 6
6. Apex of femora, tibiæ and tarsi entirely, reddish yellow...*minimus*
   At most the tarsi are partly reddish or reddish brown............ 7
7. Small, slender species; length, about 6 mm.; apical half of abdomen black ....*nigrocaudatus*
   Larger, stouter species; abdomen all red....................... 8
8. Third antennal joint not twice its apical width, antennæ rather stout, a little thickened mesad; thorax and propodeum shining, sparsely pilose ....*texanus*
   Third antennal at least twice its apical width, antennæ hardly thickened mesad; thorax and propodeum with rather abundant pile ....*tarsatus*
9. Abdomen entirely red; clypeus subtruncate (fig. 62); stout species ....*tarsatus*.
   Abdomen dark or black apically; clypeus rounded or subtruncate..10
10. Stout species; length, 6.75 mm.; scutum very finely and closely punctate; longer spur of metatibiæ as long as first joint of hind tarsi; abdomen about equally red and black; an even growth of brassy pile on disc of scutum.....................*robustior*
    Slender species; longer spur of metatibæ distinctly shorter than first joint of hind tarsi; abdomen more red than black........11

11. Scutum with very fine close punctures, appearing granulate; frons granulate-punctate; anterior edge of clypeus rather narrowly rounded, not raised mesad (fig. 71), its apical half sparsely punctate and shining; antennal joints not strongly ciliate; a little brassy pile on middle of scutum................*dubius*

    Scutum and frons with deep separate punctures; anterior edge of clypeus rounded out for most of its interocular width, a little raised mesad, sometimes slightly emarginate (fig. 70), its apical half very finely reticulate, and in addition there are some large, sparse punctures; antennæ strongly ciliate (fig. 31); scutum with the pile all white..............*propinquus*

12. Width of third submarginal cell along the radius equal to the radius from the third submarginal cell to the truncation (fig. 48); wings subfuscous................................*acuta*

    Width of third submarginal cell along the radius not as much as the length of the radius from the third submarginal cell to the truncation; wings nearly or entirely clear..................13

13. Apex of femora, and tibiæ and tarsi entirely, reddish yellow. *minimus*

    At most tarsi in part reddish brown..........................14

14. Scutum strongly depressed anteriorly in the middle; disc of propodeum rather coarsely though uniformly granulate, only striate at base...............................*sepulcralis*

    Scutum scarcely or not at all depressed anteriorly in the middle; disc of propodeum coarsely granulate and with irregular (distinct or obscure) longitudinal striæ or raised lines throughout the middle of the disc............................*glabrior*

Tachysphex intermedius Vier. belongs to the genus *Tachytes*, where I have placed it.

Tachysphex propinquus Vier.

(Fig. 15, wings; 31, portion of ♂ antenna; 70 and 73, clypeus; 81, fossorial comb, ♀; 104, pygidium, ♀.)

Tachysphex propinquus Viereck; Ent. News, XV, 87-8; 1904. ♀.

♀. Rather slender. Anterior margin of clypeus rounded out, a little wavy, slightly elevated mesad, where it is a little emarginate, no lateral teeth, rather large sparse-punctate; front finely and very closely punctate; antennæ slender, joint 2 about one-half as long as 3, which is three-fourths or more the length of 4; interocular space just a little more than the length of antennal joints 2 and 3; scutum and scutellum finely and very closely punctate, the former well depressed anteriorly in the middle, sides with shallow contingent punctures; disc of propodeum coriaceous (very finely and evenly granulate), the sides largely coriaceous, posterior face finely striate and with a median almond-shaped fovea; legs slender, the tarsal comb pronounced; venation rather delicate, the marginal cell rather narrowly and obliquely truncate; abdomen very finely reticulate; pygidial area convex, sparse punctate, long and narrow, constricted preapically and just a little more than two times as long as its basal width. *Ferruginous;* head except clypeus, scape at least, and the

thorax more commonly, black (the thorax more rarely all ferruginous). Face and thorax well covered with sericeous pile; abdomen silvery fasciate. Length, 8-12 mm. Related to *posterus* and *ashmeadii.*

♂. Slender. Anterior margin of clypeus broadly rounded out, not or just a little emarginate and elevated apically; no lateral teeth, distally with a few large punctures and finely reticulate in addition, basally very finely and closely punctate; antennæ somewhat thickened in the middle, strongly ciliate along one side joint 2 about two-thirds the length of 3, which is about two-thirds or more the length of 4; interocular space nearly or quite equal to antennal joints 2-4; front finely granulate, less so above and at vertex, postocellar depression moderately deep; scutum and scutellum with rather large, separate punctures; the punctures are a little coarser on the pleuræ; disc of propodeum coriaceous, the sides closely punctate, posterior face rather coarsely striate, with a deep fovea; legs weakly spinose, the larger metatibial spur distinctly shorter than first joint of hind tarsi; marginal cell broadly truncate; abdomen rather narrow, finely and indistinctly punctate, much more strongly punctate on the apical segments, eighth ventral segment broadly emarginate and with a low and indistinct tooth mesad. *Black;* a spot on the scape apically, the margin of the clypeus and the three basal abdominal segments, reddish; tarsi partly brownish. White pile on face and thorax; abdomen silvery fasciate. Length, 7.5-9.5 mm.

Numerous ♀ ♀ and a few ♂ ♂, chiefly from southwestern Kansas; July-August, 1911 and 1912.

Tachysphex dubius Fox.

(Fig. 71, clypeus, ♂.)

Tachysphex dubius Fox; Proc. Acad. Nat. Sci. Phil., 515; 1893. ♂.

♂. Rather slender. Anterior margin of clypeus rather narrowly rounded out (imperfectly subtruncate), the lateral angles rather sharp to obtuse, nearly smooth on its apical one-third, the rest finely punctate; antennæ somewhat thickened and pilose, joint 3 distinctly shorter than 4, the interocular space somewhat less than 3 and 4; front finely granulate; vertex finely and closely punctate; thorax a little depressed anteriorly in the middle, finely and closely punctate; disc of propodeum finely granulate, the sides reticulate-granulate, posterior face granulate and with indications of larger striæ, a transverse carina separates this face from the disc, posterior fovea large and wedge-shaped; legs feebly spinose, larger metatibial spur much shorter than first joint of hind tarsi; marginal cell rather widely obliquely truncate; abdomen fairly long, finely reticulate, eighth ventral segment with a wide emargination and a low median tooth, the sides dentiform. *Black;* first three abdominal segments red; the apical segments largely reddish brown or darker; all the tarsi more or less testaceous apically; wings clear. Well covered with pile, which on the middle of the scutum is very sparse and of a brassy hue; abdomen distinctly fasciate. Length, 7.5-9 mm.

A fair series from north central Kansas presents some variations. The insect seems very close to *consimilis.*

Tachysphex belfragei (Cress.).

(Fig. 66, clypeus, ♀.)

Larrada belfragei Cresson; Trans. Am. Ent. Soc., IV, 215; 1872. ♀.

♀. Medium stout. Anterior margin of clypeus well rounded out, and with a narrow mesal emargination and two lateral teeth; joint 3 of antennæ slightly shorter than 4, the interocular space equal to 2 and 3 or perhaps a little less; front and vertex very finely and closely punctate, scutum likewise; disc of propodeum strongly reticulate, the sides finely and the posterior face coarsely striate, the posterior fovea acute beneath and broad above; marginal cell rounded-truncate; pygidial area moderately well punctate, a little constricted preapically, about two and one-fourth times or less as long as broad at base. *Black;* spot on scape at tip, apex of femora, the tibiæ and tarsi, reddish; venation testaceous; segments 1, 2 and 3 more or less, and the apex of pygidium, reddish. Moderate silvery pubescent. Length, 9-10 mm.

A single ♀; Ellis county; July 19, 1912.

Tachysphex robustior n. sp.

♂. Quite stout. Anterior margin of clypeus rather narrowly subtruncate, the lateral angles sharp; clypeus with large separate punctures; antennæ but little thickened mesad, joint 2 nearly two-thirds of 3, which is shorter than 4; interocular space very little less than joints 3 and 4; front with shallow punctures and very finely reticulate; ocellar space deeply and separately punctate, the vertex finely punctate; postocellar pit not very deep; dorsum of thorax very finely and closely punctate, the sides indistinctly and shallowly so; disc of propodeum very finely granulate, apically broadly subtruncate, sides with fine shallow punctures, posterior face striate, with a rather smooth fovea; legs moderately spinose, longer spur of metatibiæ a little longer than first joint of hind tarsi; wings large, venation delicate, marginal cell narrowly subtruncate, the appendiculation weak, the second and third submarginal cells subequal along the radius; abdomen short and stout, with fine, shallow punctations for the reception of the pile; eighth ventral segment broadly emarginate, no median tooth. *Black;* tarsi reddish brown; venation testaceous; abdominal segments 1 and 2 reddish, the latter obscurely so; the rest of the abdomen is not *deep* black. Frons with dense, silvery pile which extends up to the ocelli; the thorax, legs and abdomen with a good amount of silvery pile (the abdomen being fasciate with silvery); pile of the dorsum of the thorax with a pale brassy-yellow tinge. Length, 5.75 mm.

One ♂; Grant county; July, 1911.

Tachysphex consimilis Cress.

Tachysphex consimilis Fox; Proc. Acad. Nat. Sci. Phil., 526-7, 1893. ♂ ♀

A single ♀ from Norton county is doubtfully referred here.

Tachysphex consimiloides n. sp.

♀. Moderately stout. Anterior margin of clypeus broadly but not strongly rounded out (subtruncate), the lateral angles not very sharp, no teeth, apical half sparsely and irregularly large punctate, the remainder very closely punctate; antennæ slender, joint 2 is one-half of 3, which is

three-fourths of 4; interocular space almost as great as the length of joints 3 and 4; frons quite finely granulate; vertex finely and closely deep-punctate, rather opaque, postocellar depression moderately deep; thorax a little depressed anteriorly mesad, very finely granulate; disc of propodeum even more finely granulate than rest of thorax, nearly coriaceous, the sides about like disc, posterior face more irregularly and coarsely granulate, with traces of striations and a broad, moderately deep, almond-shaped fovea; legs moderate, longer spur of metatibiæ shorter than first joint of hind tarsi; venation moderately heavy, the marginal cell rather narrow and scarcely obliquely truncate; abdomen short; pygidium slightly convex and with large scattered punctures in addition to being finely reticulate, barely twice its basal width. *Black;* wings clear, venation brownish testaceous, first three abdominal segments red. Insect well supplied with sericeous pile; abdomen silvery fasciate. Length of type, 7.75 mm.

There are several paratypes, all of which are in fresh condition, from Barton county, Kansas; June 20, 1912.

This species seems to be most nearly related to *consimilis* and *mundus;* it differs from the former in not having the sides of the propodeum striate, and in having the abdomen silvery fasciate; it can be separated from *mundus* by the entire clypeal margin, etc. The sculpture is even finer than in the larger *tarsatus.*

Tachysphex tarsatus (Say).

(Fig. 36, ocellar area; 62, clypeus, ♂ ♀; 87, fore femur, ♂.)

Larra tarsata Say; Western Quar. Report, II, 78; 1823. ♀.

Tachysphex tarsatus Fox; Proc. Acad. Nat. Phil., 512; 1893. ♂ ♀.

♀. Stout. Anterior margin of clypeus subtruncate, often slightly emarginate mesad, unidentate laterally, the rim wide; joint 2 of antennæ only a little more than one-half the length of 3, which is a little shorter than 4; interocular space about equal to joints 2 and 3, perhaps a little greater; head quite finely granulate, the thorax decidedly so; disc of propodeum coriaceous, sides likewise, posterior face finely striate, the fovea deep; legs moderately spinose; wings nearly clear, marginal cell obliquely subtruncate; pygidium about twice as long as its basal width, and sparsely punctate. *Black;* tarsi largely obscure reddish, venation dark brown; abdomen entirely red. Sparse appressed silvery pile. Length, 8-11 mm.

♂. Clypeus subtruncate, not dentate; interocular space about equal to joints 3 and 4; front coarsely granulate. Colored as in ♀. Length, 7-10 mm.

Common in the western part of the state. Rather easily recognized by its very fine sculpture, size, unidentate clypeus, etc.

Tachysphex texanus (Cress.)

(Fig. 47, tip of wing.)

Larrada texana Cresson; Trans. Am. Ent. Soc., IV, 214; 1872. ♂ ♀.
Tachysphex texanus Fox; Proc. Acad. Nat. Sci. Phil., 513-14; 1893. ♂ ♀.

♀. Stout, nearly as large as *tarsatus*, which it resembles superficially. Anterior margin of clypeus subtruncate, without teeth, the lateral angles sharp, rim rather wide; clypeus quite convex and with a few large punctures on its anterior half; joint 2 of antennæ about one-half of 3, which is a little shorter than 4; the interocular space about equal to joints 2 and 3, perhaps a little greater; frons finely and quite closely punctate basally, the punctures larger higher up; vertex shining, with rather large and deep separate punctures; disc of propodeum rather coarsely granulate, the sides striate, the posterior face more coarsely so, its fovea large and shining, wedge-shaped; legs moderately spinose; venation rather delicate, marginal cell obliquely subtruncate, the second submarginal cell usually a good deal wider than the third along the radius; abdomen finely reticulate; pygidium about two times as long as the basal width, well margined, a little constricted preapically, the whole finely reticulate and with sparse, irregularly disposed punctures. *Black;* legs brownish red apically; wings clear; abdomen all red. Moderately pilose. Length, 7.5-10 mm.

♂. Stout. Clypeus subtruncate, a little produced mesad; punctures coarser in this sex; interocular space a little more than the length of antennal joints 3 and 4; eighth ventral segment of abdomen broadly emarginate, and with no median tooth. Colored as in ♀. Length, 6.5-7 mm.

A good series of ♀ ♀ from western Kansas; two ♂ ♂ from Stevens and Norton counties seem to belong here.

Tachysphex sculptiloides n. sp.

♀. Stout, somewhat like a small *texanus*. Anterior margin of clypeus subtruncate, not emarginate mesad, a distinct lateral tooth; clypeal rim broad and with large punctures at its base, apical half (with the exception just mentioned) smooth and shining; antennæ moderately slender, joint 2 one-half as long as 3, which is a little shorter than 4; interocular space nearly as wide as is the length of antennal joints 2 and 3; frons with moderately fine, shallow and well separated punctures, the interspace finely reticulate; vertex shining, with medium-sized, deep punctures; ocellar depression deep; dorsum of thorax shining, with large, rather close punctures; disc of propodeum rather coarsely granulate, and with irregular, more or less longitudinal and parallel, well separated lines (not so evident in the two cotypes), giving the disc an imperfectly striate effect; sides rather coarsely and strongly striate; a carina separates the disc from the posterior face, which is coarsely striate and with a large, deep wedge-shaped fovea; legs moderately spinose; marginal cell rather narrowly and not very obliquely truncate; abdomen shining; pygidium about two and one-fourth times as long as its basal width, scarce constricted preapically, smooth and very sparsely punctate, the bounding carina fairly prominent. *Black;* wings clear, except that they are slightly fuscous apically; abdominal segments 1-3 largely reddish brown. Pile

rather sparse except on pleuræ; on the head not extending high up on the frons; abdominal fasciæ not very strong. Length (type), 7.25 mm.

Three specimens from Barton county; June, 1912.

Tachysphex nigrocaudatus n. sp.

♀. Moderately slender. Anterior margin of clypeus subtruncate, a low lateral tooth; the clypeus much resembling that of *crassiformis* and *plenoculiformis*, only a little convex, rim rather wide, apical portion of clypeus very little punctate, shining, the basal part rather closely punctate; antennæ rather stout and blunt, joint 2 is about one-half of 3, which is more than three-fourths of 4; interocular space about equal to joints 3 and 4; frons with medium-sized, shallow punctures, which are separated from one another by about their width, these interspaces finely reticulate; vertex shining, with deeper, more separate punctures, ocellar area moderately cleft, the postocellar depression moderately deep; dorsum of thorax shining, hardly depressed anteriorly mesad, with large, deep punctures, their width or less apart; disc of propodeum medium granulate, with short basal striæ, sides rather coarsely but shallowly striate-granulate; an imperfect carina between the disc and posterior face, the latter coarsely striate and with a large wedge-shaped fovea; legs moderately spinose; third submarginal cell along the radius a little longer than the second, and nearly equal to the remainder of the radius to the moderately oblique truncation of the marginal cell; abdomen polished; pygidium well defined, smooth, about two and one-fourth times as long as its basal width, the sides nearly straight, a little constricted preapically, narrowly subtruncate apically, and with a few medium-sized deep punctures towards the sides. *Black;* wings a little dusky; first two and one-half segments of the abdomen red. Insect rather sparsely pilose; abdomen scarcely fasciate. Length (type), 6.5 mm.

Rush county, Kansas; June, 1912. There are two others from Barton and Ness counties; one of these has the pygidium a little more strongly punctate than the type.

♂. Moderately slender. Anterior margin of clypeus truncate, no lateral teeth; antennæ stout, rather blunt apically, pilose, joint 2 more than one-half the length of 3, which is about three-fourths of 4; interocular space about equal to antennal joints 2-4; sculptured about as in ♀; the wedge-shaped fovea on the posterior face of the propodeum broad and deep; eighth ventral segment broadly emarginate; first two or three abdominal segments reddish. Pile rather abundant; the abdomen thereby well fasciate. Length, 4.5-7 mm.

A good series of this decidedly small larrid from western Kansas.

Tachysphex plenoculiformis n. sp.

♀. Rather slender. Anterior margin of clypeus subtruncate, with one lateral tooth (here greatly resembling *crassiformis*, fig. 72), some confluent punctures at base of the rim, the apical half (with the above exception) smooth, polished and inpunctate, the basal half closely punctate, only moderately convex; frons with very close, shallow punctures, which are separated by less than their width, the whole rather finely reticulate; vertex polished, with rather fine, close, but shallow punctures; ocellar area not very much impressed medially, the postocellar depression

deep; antennæ moderate, clothed with silvery pile, joint 2 about one-half of 3, which is somewhat shorter than 4; interocular a little less than joints 3 and 4; scutum a little depressed anteriorly mesad, and with quite close, moderate-sized punctures; disc of propodeum evenly granulate, the sides rather strongly striate, the posterior face separated from the disc by an imperfect carina, the face shining, rather coarsely and shallowly striate and with a wide, deep, almond-shaped fovea; legs rather slender, only moderately spinose; venation rather weak, marginal cell not very obliquely truncate; abdomen slender, subconic, shining; pygidial area well defined, a little constricted preapically, and with distinct, well-scattered punctures, the pygidium about two times as long as wide at its base. *Black;* apex of mandibles largely reddish brown; abdomen all red. Sericeous white pile sparse except on face; abdomen not well fasciate. Length, 7 mm. (type).

One ♀; Ness county; July 1, 1912. Six paratypes; length, 5.5-7.25 mm.; southwestern Kansas and Norton county, Kansas.

The insect appears to be rather closely related to *wheeleri* Roh., and resembles *crassiformis* Vier. in some particulars. It is more slender than the latter and a little more finely punctate.

Tachysphex crassiformis Vier.

(Fig. 72, clypeus, ♀.)

Tachysphex crassiformis Viereck; Trans. Am. Ent. Soc., XXXII, 210-11; 1906, ♀.

♀. Stout. Anterior margin of clypeus subtruncate, a little produced mesad, with one lateral tooth; antennæ not very slender, joint 3 a little shorter than 4; interocular space a little more than the length of joints 2 and 3 but less than 3 and 4; front finely punctate below, more sparsely so under the fore ocellus; vertex finely and closely punctate; scutum and scutellum polished, with moderately fine separate punctures, especially of the sides, pleuræ finely punctate; disc of propodeum finely and evenly granulate, the sides strongly striate, posterior face distinctly striate, with a deep oval fovea; legs moderately spinose; wing venation not heavy, marginal cell a little obliquely truncate, moderately wide, second submarginal cell just a little wider than the third along the radius; abdomen stout; pygidium fully two times as long as its basal width, the sides a little bowed out and slightly constricted preapically, disc with large sparse punctures. *Black;* scape at apex and distal tarsi reddish; abdomen reddish. Pile moderate; abdominal fasciæ moderate. Length, 7 mm. (type).

Hamilton county, Kansas. Five others, from Stevens, Morton and Stanton counties; July-August, 1911.

Related to *antennatus*, according to Viereck.

Tachysphex crenuloides n. sp.

(Fig. 68, clypeus; 105, pygidium, ♀.)

♀. Robust. Anterior margin of clypeus rounded, rather narrowly but distinctly emarginate mesad, two distinct lateral teeth and a slight indication of a third broader and inner one; a row of coarse, more or less confluent punctures behind the rim of the clypeus, which slopes up from that point, the clypeus shining and almost inpunctate; joint 2 of antennæ

about one-half of 3, which is a little shorter than 4; interocular space just a little greater than antennal joints 2 and 3; frons finely punctate, the vertex more sparsely so behind the ocelli; scutum and scutellum with moderately fine and close separate punctures, these punctures being more separate on the sides; disc of propodeum very finely granulate, the sides finely punctate-striate, posterior face distinctly striate and with a large wedge-shaped fovea with its apex pointing ventrad; legs tolerably spinose; venation normal, the marginal cell narrowly rounded-truncate; abdomen inpunctate above except towards apex, the last ventral plate with confluent punctures on its apical half; pygidium wide, a little less than twice as long as its basal width (the type and cotype have the pygidium only partly extruded), its strong margins strongly bowed out, scarcely constricted preapically, apically moderately broad-truncate, the disc quite sparsely punctate. *Black;* tarsi brownish red; wings clear; abdomen red (this color is neither bright nor clear). Head, thorax, legs and apex of abdominal segments with a good supply of silvery pile. Length, 8 mm. (type).

Morton county; August 5, 1911. Two paratypes, Morton and Grant counties.

Related to *crenulatus*, to which it runs down in Fox's key. The latter species, besides being a good deal the larger, has the frons more finely punctate and less sericeous, the abdomen bright red, and the clypeus more regularly crenulate.

Tachysphex dentatus n. sp.

(Fig. 67, clypeus; 106, pygidium.)

♀. Robust. Anterior margin of clypeus with a long, distinct *median* tooth, and a low, rather distinct one on either side (in addition to the sharp lateral angle), a curved shining fold or ridge behind the median tooth; joint 3 of antennæ just a little shorter than 4; interocular space not greater than antennal joints 2 and 3; front coarsely (thimble-like) granulate; vertex with finer separate punctures; scutum and scutellum so closely punctate as to appear granulate, the sides about as dorsum; disc of propodeum finely granulate, the sides finely striate-punctate, the posterior face strongly striate and with a large wedge-shaped fovea; legs tolerably spinose; wings with the marginal cell rather broadly and obliquely truncate; abdomen with a few punctures on the apical segments; pygidial area nearly flat and almost inpunctate, well margined, the apex broadly rounded, the disc about one and one-third times or a little less than its basal width. *Black;* tarsi more or less reddish brown; wings clear; abdomen all red. Head and thorax with a fair amount of whitish sericeous pile, which is sparse on the abdomen. Length, 9 mm.

A single ♀ from Morton county; August 5, 1911.

A very distinct species.

Tachysphex sepulcralis n. sp.

♀. Moderately stout. Anterior margin of clypeus rather broadly rounded out, no lateral teeth, the lateral angles sharp though not acute, the clypeus coarsely and sparsely punctate apically, closely so basally, rim wide; antennæ moderately slender, joint 2 is one-half of 3, which is

fully three-fourths of 4 and more than twice its apical diameter; interocular space a little more than joints 2 and 3; frons finely and very closely punctate, but less so about the ocelli; vertex with rather large, deep and separate punctures, postocellar depression deep; scutum well depressed anteriorly mesad for at least one-half its length, a little polished and compactly punctate; disc of propodeum granulate, the sides not very distinctly punctate and striate, the posterior face distinctly striate, the sulcus long and narrow; legs moderately spinose; venation not strong, marginal cell moderately truncate, the second submarginal cell distinctly longer than the third along the radius, the distance from the third to the truncation much more than the length of the third along the radius; abdomen shining; pygidium barely two times the length of its basal width, its strongly margined sides nearly straight, very little constricted preapically, very finely reticulate, and with sparse, well-distributed punctures. *Black;* legs a little lighter colored apically; wings a little darkened toward the tip; venation brown. Rather abundant silvery pile, with which the abdomen is well fasciate. Length, 9 mm. (type).

Phillips county, Kansas; Aug. 30, 1912. Three paratypes (one of which is 10 mm. long); Barton and Russell counties.

♂. Anterior margin of clypeus subtruncate, somewhat produced in the middle (more strongly so than in *crassiformis*), the lateral angles sharp; antennæ a little thickened mesad, joint 2 more than one-half of 3, which is a little shorter than 4; interocular space equal to joints 2-4, or nearly; frons with very close, more or less confluent punctures, those of the vertex larger and separated from each other by their diameter or more, vertex when viewed from behind a little depressed; thorax rather coarsely and closely punctate, well depressed mesad for nearly the whole length of the scutum; disc of propodeum somewhat coarsely granulate, and with a few basal striæ, the sides punctate-striate, posterior face coarsely striate, the fovea broad; legs scarcely spinose, wings about as in the ♀, except that the second and third submarginal cells are subequal along the radius; abdomen shining; pygidial area pilose, emargination of eighth ventral segment broad. Colored as in the ♀. Pile moderate, abdomen well silvery fasciate. Length, 7.5 mm.

Barton county, Kansas; June, 1912.

Related to *apicalis*.

Tachysphex glabrior n. sp.

(Fig. 65, clypeus, ♂.)

♀. Moderately stout. Anterior margin of clypeus rather narrowly subtruncate, a little produced mesad (as in *crassiformis*), in addition to the lateral angles there are two distinct lateral teeth; antennæ a little stouter than in *sepulcralis*, joint 2 about one-half of 3, the latter is hardly two times its own diameter at apex and two-thirds to three-fourths the length of 4; interocular space about equal to antennal joints 3 and 4; frons finely punctate; vertex with the punctures more separate, the sculpture being a little finer than in *sepucralis;* disc of propodeum moderately granulate, with poor indications of basal striæ, the sides well striate, the posterior face coarsely so, the almond-shaped fovea large; legs moderately spinose; venation rather weak, marginal cell with the

truncation moderate, width of third submarginal cell along the radius less than the distance therefrom to the truncation; abdomen shining; pygidium much as in *sepulcralis*, barely two times as long as the basal width, polished (finely reticulate in a paratype), punctures large, sparse, but well distributed. *Black;* legs of lighter color apically; wings a little smoky towards the tip; abdominal segments narrowly testaceous apically. Moderately pilose; abdomen well silvery fasciate. Length, 8 mm. (type).

Phillips county, Kansas; August, 1912. Two paratypes, Ellis county.

♂. Anterior margin of clypeus rounded-subtruncate, the lateral angles somewhat dentiform; antennæ long, joint 2 more than one-half the length of 3, which is three-fourths the length of 4; interocular space hardly as much as joints 2-4; frons dull, almost granulate, but finely reticulate in addition; vertex more polished, with fine separate punctures; thorax rather dull, closely punctate; disc of propodeum granulate and with irregular raised lines, the sides more or less striate, posterior face with a few coarse striæ, a strong fovea, and a carina separating that face from the disc; eighth ventral segment broadly but shallowly emarginate. Colored as in the ♀. Length, 5-6 mm.

Rush, Ellis, Osborne and Pratt counties.

Apparently allied to *acuta* Patt. and *similis* Roh.

Tachysphex acuta (Patt.).

(Fig. 48, tip of wing, ♀.)

Larra acuta Patton; Proc. Bost. Soc. Nat. Hist., XX, 390; 1880. ♀.

♀. Stout. Anterior margin of clypeus broadly rounded-subtruncate, laterally not acute, with an indistinct lateral tooth or entire, the apical portion sparsely and large punctate, the basal portion very closely punctate, the rim rather narrow; antennæ slender, joint 3 just a little shorter than 4; interocular space perhaps a little wider than the length of antennal joints 2 and 3; frons finely granulate; vertex very closely punctate, postocellar depression not marked; thorax very closely punctate; disc of propodeum finely reticulate-granulate, the sides granulate and striate, the posterior face more coarsely so, and with a rather broad, shallow fovea; legs moderately spinose; wings broad, venation rather heavy, marginal cell broadly and obliquely truncate, the width of the third submarginal cell along the radius about equal to the length of the radius therefrom to the truncation; abdomen stout, finely reticulate; pygidium about two and one-half times as long as its basal width, smooth and polished and with an irregular row of deep punctures near its strong margins, disc a little constricted preapically. *Black;* wings subfuscous. Pile sparse (the specimens are worn); abdomen more or less fasciate. Length, 7.5 mm.

♂. Anterior margin of clypeus subtruncate, rather broadly produced mesad (here the smooth rim is broadened), the lateral angles sharp; antennæ a little thickened mesad, joint 3 shorter than 4; interocular space hardly equal to joints 2-4; frons granulate; vertex with distinct punctures; thorax rather coarsely close punctate; propodeum with rather indistinct longitudinal striations, the sides not distinctly striate nor granulate, posterior face with a distinct transverse carina

which separates it from the disc, the face coarsely granulate and with large sparse striae and a median fovea; eighth ventral segment broadly emarginate. Colored as in the ♀. Length, 6-6.5 mm.

Five ♂ ♂ and two ♀ ♀; Smith, Barton and Russell counties; June-September. The specimens fit Fox's description fairly well and likewise that of Patton, the describer of the species. I have not seen the type. The two ♀ ♀ are identical with a specimen in the collection of the Philadelphia Academy of Sciences, where, however, there are at least two species in the series labeled *acuta*. It seems to be allied to *nigrescens* ♀, of Rohwer, which, however, has a different clypeus.

Tachysphex terminatus (Smith).

(Fig. 63, clypeus ♀; 32*a*, antenna, ♀.)

Larrada terminata Smith; Cat. Hym. Brit. Mus., IV, 291; 1856.
Tachysphex terminatus Fox; Pr. Ac. Nat. Sci. Phil., 520; 1893. ♂ ♀.

♀. Greatly resembles *fusus*, from which it differs in not or in scarcely having the clypeus drawn out mesad on its anterior margin; the antennæ are a little stouter, the third joint is decidedly shorter than the fourth; the front is much more closely punctuate, in fact almost granulate; the disc of the propodeum is a little more finely granulate; the pygidium is nearly two and one-fourth times as long as its basal width. Colored as in *fusus*.

♂. Like *fusus*, but the front is more closely punctate, for whereas in *fusus* the punctures just below the anterior ocellus are well separated, sparse, and the face shining there, the same are quite close to almost granular in *terminatus*. The lateral angles of the clypeus are said to be sharp and almost dentiform. Length, 6 mm.

Fairly plentiful in western Kansas, where it has the same habitat as *fusus*.

Tachysphex fusus Fox.

(Fig. 64, clypeus, ♀; 32*b*, antenna, ♀.)

Tachysphex fusus Fox; Proc. Acad. Nat. Sci. Phil., 519-20; 1893. ♂ ♀.

♀. Moderately stout. Anterior margin of clypeus subtruncate, slightly produced mesad, no lateral teeth; antennal joints 3 and 4 subequal; frons rather coarsely punctate, vertex a little more sparsely so, occiput rather depressed; scutum with strong separate punctures, mesopleuræ likewise; disc of propodeum strongly granulate, the sides finely striate, posterior face more coarsely and rather indistinctly striate, with a median fovea; marginal cell rather narrowly and obliquely truncate; abdomen smooth and shining; pygidium about two times as long as wide at its base, sparsely punctate. *Black;* apex of abdomen red. Silvery pubescence rather dense. Length, 9-11 mm.

♂. Anterior margin of clypeus subtruncate, with sharp lateral angles; frons with large confluent punctures; flagellum a little thickened; thorax with strong separate punctures; propodeum somewhat more coarsely sculptured in this sex. The insect is sometimes entirely black. Length, 6-8 mm.

Fairly common in western Kansas, where it frequents sandy places; one fresh ♀, taken at Lawrence, Douglas county, Kansas, June 12, 1913.

Tachysphex clarconis Vier.

(Fig. 69, clypeus, ♀.)

Tachysphex clarconis Viereck; Trans. Am. Ent. Soc. XXXII, 211; 1906. ♀.

♀. Not stout. Anterior margin of clypeus broadly subtruncate, slightly produced mesad, not dentate laterally, very closely punctate at base; antennæ moderately slender, joint two about one-half the length of 3, which is three-fourths of 4; interocular space about equal to joints 2-4; frons finely and shallowly granulate, becoming separate punctate towards ocelli; vertex with sparse punctations, ocellar line deep, a shining fold behind each posterior ocellus has somewhat the appearance of a second pair of ocelli; vertex depressed a little below the level of the eyes; thorax polished, with rather fine, shallow and separate punctures; disc of propodeum moderately granulate, with an indication of a median impressed line, sides shining, shallowly fine-punctuate or imperfectly reticulate, the posterior face shining, nearly smooth, with a deep wedge-shaped fovea; legs feebly spinose; venation rather weak, the marginal cell rather narrowly and very little obliquely truncate, second submarginal cell a little wider than the third along the radius; pygidium well defined, hardly two times as long as its basal width, sparse punctate, very little constricted preapically. *Black;* legs dull brownish apically; abdomen red, largely black on the ventral segments 1-5; apex of pygidium dark brown. Pile sparse except on face. Length, 7 mm. (type).

One ♀; Clark county, Kansas; May; F. H. Snow.

"Related to *terminatus*."—Vier.

Tachysphex quebecensis (Prov.).

Larra quebecencis Prov.; Faun. Ent. Can., II, 633. ♂ ♀.

Tachysphex quebecencis Fox; Proc. Acad. Nat. Sci. Phil., 527-8; 1893. ♂ ♀.

This species is reported by Bridwell, who collected it near Baldwin, Douglas county, Kansas.

Tachysphex æthiops (Cress.) ♂ is reported from northwestern Kansas, September, 1877 (S. W. Williston, Coll.) by W. H. Patton (Bull. U. S. Geol. and Geog. Sur. Terr., V, No. 3,349-70; 1879-'81.) His description of the specimen, however, is far from agreeing with that of Fox for the ♂, and leads me to believe that the insect taken in 1877 is really a *Larropsis*, which fits in description, as far as it goes.

Tachysphex minimus (Fox).

Tachytes minimus Fox; Trans. Am. Ent. Soc., XIX, 248; 1892. ♂.

Tachysphex minimus Fox; Proc. Acad. Nat. Sci. Phil., 532-3; 1893. ♂.

Bridwell (Kan. Acad Sci., 208; Dec., 1898) reports this insect from Kansas. The abdomen varies from entirely black to red at the base. It occurs also in Nebraska.

LYRODA Say.

Say; Jour. Nat. Hist., I, p. 370; 1836.

Form rather slender, sparsely pubescent. Head distinctly wider than thorax, long and evenly rounded; antennæ medium, scape rather stout; eyes not converging, their inner margins parallel; three round ocelli, arranged in a low triangle; mandibles emarginate beneath and dentate within. Thorax slender, due largely to the rather long, narrow pronotum which is medially produced posteriorly (subtuberculate); propodeum rounded-truncate, with a more or less evident carina at its dorsolateral angles (this carina is present at least at the apex); marginal cell of fore wings truncate and distinctly appendiculate, second submarginal cell not petiolate; legs rather long, spinose. Abdomen rather narrow. fusiform, first abdominal segment slender, more gently rounded and well tapering.

♀. Fore tarsal comb not strong; pygidium well defined, rounded-triangular, and covered with short pile.

♂. Fore femora entire; pygidial area hardly defined, pubescent.

KEY TO THE SPECIES OF LYRODA.

Form stout; color deep black, without silvery pile on abdomen; wings dark fuscous; length, 14-15 mm.......................... *triloba* ♀

Form rather slender; not *deep* black; silvery pile on abdomen; wings dusky only at tip; length ♂, 7-8 mm.; ♀, 11-13 mm.......... *subita*

Lyroda subita Say.

(Fig. 96, pygidium, ♀.)

Lyroda subita Say; Jour. Nat. Hist., I, p. 372; 1836. ♀.
Lyroda subita Fox; Proc. Acad. Nat. Sci. Phil., 533-4; 1893. ♂ ♀.

A small series of both sexes; Douglas, Norton, Rooks, Trego and Decatur counties; June-August.

Lyroda triloba Say.

(Fig. 37, ocellar area.)

Lyroda triloba Say; Jour. Nat. Hist., I, p. 372, 1836. ♀.
Lyroda triloba Fox; Proc. Acad. Nat. Sci. Phil., 533-4, 1893. ♀.

2 ♀ ♀; Clark and Smith counties; August-September.

Seemingly a rare insect. I find no record of the ♂.

PLENOCULUS Fox.

Fox; Psyche, VI, 554; 1893.

Head wider than thorax; eyes converging towards vertex; antennæ short, stout and subclavate; ocelli round, arranged in a subequilateral triangle; mandibles strongly excised beneath, dentate within. Pronotum below the level of the scutum; propodeum short; marginal cell truncate, second submarginal cell petiolate, first and second submarginals each receiving a recurrent nervure, submedian cell shorter than the median cell on the externo-median nervure; legs stout and spinose.

♀. Pygidium well defined, naked and broadly triangular.

♂. Pygidium smaller and less distinct in this sex; eighth ventral segment rounded out or at most slightly emarginate.

A genus represented by small species, of which there are about a dozen in the United States.

KEY TO THE SPECIES OF PLENOCULUS.

Abdomen black .... *davisi*
Abdomen red, black apically .... *apicalis*

Plenoculus davisi Fox.

Plenoculus davisi Fox; Psyche, Nov. 1893, p. 554.
Plenoculus davisi Fox; Proc. Acad. Nat. Sci. Phil., 537; 1893. ♂ ♀.

♀. Clypeus emarginate mesad; three to five lateral teeth; thorax minutely punctate; propodeum finely granulate, a median impressed line and some short transverse striæ at base, sides delicately striate. *Black;* mandibles, except tip, tegulæ, tibiæ and tarsi, more or less yellowish, abdominal segments apically testaceous, the last segment reddish at tip. Length, 5-6 mm.

♂. Anterior margin of clypeus strongly rounded out or slightly produced mesad; ventral abdominal segments 3-6 with a transverse row of tubercles. *Black;* clypeus and scape beneath, tubercles, tegulæ and disc of prothorax, apex femora, tibiæ except the inner side of the two anterior pairs, and tarsi, bright yellow. Length, 4.5-5 mm.

Structurally much like *propinquus* and *apicalis*.

A single ♂ taken in Graham county, August 16, 1912, seems to belong here. The clypeus has its lateral angles sharp, the median portion produced much as in *apicalis*, and the light yellow markings, disposed rightly for the species, are here light yellowish-brown to brownish instead of yellow. Length, 4.25 mm.

Plenoculus apicalis n. sp.

(Fig. 20, wings; 43-45, antennæ; 76 and 77, clypeus; 102, pygidium, ♀; 103, tip of ♂ abdomen.)

♀. Anterior margin of the clypeus with four, or an additional fifth tooth on each side of the median emargination; front finely granulate; median impressed line from behind fore ocellus not extending to base of antennæ, where it is partly replaced by a raised line; a short curved furrow between each posterior ocellus and eye; first joint of flagellum a very little shorter than either second or third; scutum and scutellum with fine, close punctures, the sides finely and indistinctly granulate-striate; disc of propodeum finely granulate, the strong median furrow traversed by a few separate and indistinct striæ; the disc largely naked, its base with some short radiating striæ, the sides about like the thorax, posterior face with a wedge-shaped depression and polished median impression within; legs stout, rather spinose, tarsal comb moderate, the spines thereon about as long as the diameter of the first tarsal joint; venation normal; abdomen inpunctate, except toward the apex (at the origin of the hairs); pygidial area shining, sparsely large-punctate, the bounding carinæ low. *Black;* mandibles, except tip and lower edge, yellowish to

brownish; apex of scape beneath narrowly yellowish; wings clear, iridescent, venation testaceous, the tegulæ paler; apex of fore femora, fore tibiæ except beneath, and the upper basal portion of middle and hind tarsi, pale yellow; tibiæ brownish; first two or two and one-half abdominal segments clear red, the black on apical segments often more extended ventrally, apical margins of segments more or less testaceous, tip of pygidium reddish. Appressed silvery pile plentiful. Length of type, 4.25 mm.; range, 3.50-4.75 mm.

Phillips county, Kansas; August 30, 1912.

♂. Like the ♀ in many respects. Clypeus rather narrowly subtruncate mesad, the truncation itself a little produced in the middle, no lateral teeth; propodeum usually a little more coarsely sculptured than in ♀; abdomen more pilose, ventral segments 3-6 tuberculate; the clypeus is yellow, the second abdominal segment above often with a black band and a few spots of the same color ventrad, last segment often reddish. Facial pile frequently with a golden tinge. Length, 3.50-4.25 mm.

Twenty-two ♂ ♂ and fifteen ♀ ♀; from Norton and Phillips counties; end of August, 1912.

♂. *Var.* Yellow markings replaced by reddish brown; the last four segments are blackish, the rest have some large spots of the same color. Facial pile more silvery than in the usual form.

One ♂; Graham county; August 16, 1912.

Apparently most closely related to *davisi*, from which it differs in color and in being smaller. The clypeal margin in the ♂ is subject to a little variation.

NITELIOPSIS Saunders.

Saunders; Trans. Ent. Soc. London, III, p. 410; 1873.

Small insects, nearly naked or covered with short pile. Head rather long, wider than thorax; antennæ slender to quite stout and subclavate; mandibles not or very slightly emarginate beneath; eyes rather strongly converging to the top; three perfect ocelli. Thorax stout, fusiform; propodeum rounded posteriorly; legs rather feebly spinose; marginal cell rather elongate, truncate, the appendiculation rather obscure, second submarginal cell petiolate, the transverse-median and recurrent varying in relative position.

♀. No tarsal comb; pygidial area pilose, poorly or not defined.

♂. Fore femora simple beneath at base; no pygidial area; eighth ventral segment at least sometimes emarginate.

The four Kansas species do not readily fall in this genus. Using Ashmead's key, and granting first of all that the insects have a distinct pygidial area (which is not evident to me), *foxii* would run to the genus *Niteliopsis*, while the rest, on the same condition, would run to *Silaon*. All of our species have been placed in the latter genus by Rohwer (Proc. U. S. N. Museum, vol. 40, 586; 1911). Here the question hinges on the species not having the mandibles emarginate exteriorly (*Silaon*), or having the mandibles distinctly or shallowly emarginate exteriorly. The author is not sufficiently acquainted with the group to arrive at any definite conclusion in the matter than to state that the group to which *Nit. foxii*, *vierecki*, and probably *fossor*, belong, differs widely from the rest and should

be separated therefrom. The three above mentioned are nearer the Larrinæ than the rest, and differ a good deal in the antennæ, venation, etc. (See figs. 29 and 30.) Whether the camera lucida drawing of the mandible of the type of *Nit. foxii*, fig. 28, shows this mandible to be shallowly emarginate or not emarginate exteriorly would be hard to decide. The writer can do no better than to include all the Kansas species under the genus *Niteliopsis* in awaiting a more perfect arrangement of the group than the present.

KEY TO THE SPECIES OF NITELIOPSIS.

1. Second joint (pedicel) of antennæ about one-half or less the length of the third, which is at least three times as long as its apical diameter (fig. 29); antennæ not at all clavate; first recurrent nervure running well into the second submarginal cell (fig. 18); abdomen red .... *foxii* ♀

   Second joint of antennæ from one-half the length to as long as the third joint, which is not more than two times its apical diameter; antennæ somewhat clavate (fig. 30); second recurrent nervure running into the first submarginal cell, or at most just received into the second submarginal; abdomen black 2

2. As viewed from above (under a compound microscope), abdominal segments 1 and 2, at least, are finely reticulate or appear scaled, the punctures for the reception of the pile being very shallow and therefore not pit-like; abdomen evenly rounded; females 4.25 mm. or less long, males 3 mm. long............ *affinis* ♂ ♀

   Abdominal segments 1 and 2 with deep separate punctures, therefore not reticulate; abdominal curve somewhat interrupted by the intersegmental constrictions; length, 4-6 mm. 3

3. Pronotum, postscutellum and all the tibiæ marked with creamy yellow; transverse-median vein commonly arising beyond the basal vein; disc of propodeum without a distinct, broad and bounded sulcus apically, and with well-separated longitudinal to somewhat diverging striæ, reaching usually to apex; no transverse apical striæ .... *inerme* ♂ ♀

   Pronotum and sometimes apex of tubercles of pronotum with creamy yellow, or the pronotum all black; transverse-median vein basad of or interstitial with basal vein; disc of propodeum with a well-marked broad apical sulcus, and with a few short or indistinct striæ from the base, transverse apical striæ present. *kansensis* ♀

Nit. sayi of Colorado is sculptured on the abdomen like *affinis*, while *niger*, from the same locality, resembles *inerme* in that respect.

Niteliopsis foxii Vier.

(Fig. 18, venation; 28, mandible; 98, pygidium.)

Niteliopsis foxii Viereck; Trans. Am. Ent. Soc., XXXII, 207-8; 1906. ♀.

The type comes from Clark county, Kansas; June; F. H. Snow. Another ♀ was taken in Haskell county; July, 1911. It was running over the ground, now and then entering holes and crannies. The species is very close to if not identical with *N. vierecki* Roh., which occurs in Colorado.

Niteliopsis affinis Roh.

Niteliopsis affinis Rohwer; Trans. Am. Ent. Soc., XXXV, 113-4; 1909. ♂ ♀.

This is a very small, shining black species, described from Colorado. It seems rare in Kansas, where it was taken in Graham, Norton, Ellis, Ness and Rush counties; June-August, 1912.

Niteliopsis inerme (Cress.).

Nysson? inerme Cresson; Trans. Am. Ent. Soc., IV, 224; 1872. ♀. Tex.
Niteliopsis inermis Rohwer; Trans. Am. Ent. Soc., XXXV, 110-11; 1909. ♂.

A good series from western Kansas; Grant, Barton, Norton, Phillips, Ellis, Ness and Rush counties; June-August. The insect is rather easily recognized by its pale yellow markings.

Niteliopsis kansensis n. sp.

♀. Anterior margin of clypeus narrowly lobed mesad; antennæ subclavate, joint 2 stouter than either 3 or 4; 3 and 4 subequal, the fourth narrow at the base; front not very finely granulate-punctate, the carina to clypeus distinct, a slight impressed line from ocellus forward; vertex granulate-punctate, scutum moderately so, the pleuræ inclined to be coarse-punctate; disc of propodeum coarse-rugose, with indications of longitudinal striæ at the base; a broad, rough, moderately deep fovea for more than the apical half of the disc, some coarse transverse apical striæ, sides finely striate, posterior face granulate-striate, a strong median fovea; legs feebly spinose; second recurrent nervure received in the second submarginal near its tip; transverse-cubital vein arising a little basad of the basal vein, marginal cell narrowly truncate. Segements of the abdomen somewhat constricted basally, basal segments most distincly punctate; pygidial area lacking. *Black;* mandibles rather dark rufous near the middle; tubercles, a spot posteriorly on each side of the median line of the pronotum, apex of femora (and also the middle femora very slightly), and the hind tibiæ at their base outwardly, yellow; clypeus and lower part of the face, thoracic pleuræ and sterna, silvery pilose; abdomen somewhat pilose. Length, 4.75 mm. (type).

Norton county, Kansas; August, 1912.

A second ♀ is entirely black, excepting for the apical portion of the tubercles. This, the cotype, is from Barton county; June 22, 1912. It is allied to *plenoculoides* and *niger;* from the first it differs in being smaller, in lacking the carinate pronotum, in having a coarser sculpture on the propodeum, and a somewhat different venation; from *niger* it may be distinguished by the finer punctation and in not being all black (except for a portion of the mandibles).

MISCOPHUS Jurine.

Jurine; Nouv. Meth. Class. Hym., p. 205.

Head wider than thorax; mandibles strongly excised beneath, not dentate within; antennæ quite slender. Marginal cell lanceolate, not appendiculate; two submarginal cells, each receiving a recurrent nervure; armature of legs variable. No pygidial area.

♂ Has a feebler tarsal comb and stouter antennæ than the ♀.

The genus is poorly represented in the United States.

Miscophus americanus Fox.

(Fig. 75, clypeus, ♀.)

Miscophus americanus Fox; Ent. News, I, 138; 1890; ♀. II, 196; 1891; ♂.

This is a small black insect, 3 to 4.5 mm. long, having the clypeus three-lobed, the wings infuscated apically, and the abdomen shining. The type was taken in Camden county, New Jersey. The three ♂ ♂ and one ♀ in the Snow collection come from Rush and Barton counties; June, 1912.

BOTHYNOSTETHUS Kohl.

Kohl; Verh. Zoöl.-bot., Gesell. Wien, p. 344, taf. XVIII, f. 5 *et* 6; 1883.
Fox; Proc. Acad. Nat. Sci. Phil., 550; 1893.

Body stout. Head as wide or wider than thorax; eyes diverging towards vertex; antennæ rather stout; ocelli large, arranged in a low triangle; mandibles not emarginate beneath. Pronotum almost on the same level as the scutum, which is large; propodeum rather short; stigma of primaries quite large, marginal cell lanceolate at apex, no appendiculation, first submarginal cell very large, the second petiolate, receiving one or both recurrent nervures; submedian and median cells of the same length on the externo-median nervure; legs stout, feebly armed, hind femora broadest apically. A broad and well-defined pilose pygidial area in both sexes.

As far as I am aware, this genus is represented in the United States by a single species. It is an anomalous larrid, and seemingly far removed from any other genus of the family. The large stigma of the fore wings resembles that of some of the Pemphredinidæ. The apically thickened hind femora easily separates it from the other genera.

Bothynostethus distinctus Fox.

(Fig. 17, venation; 50, disc of propodeum, ♂: 74, clypeus, ♂; 86, hind femora, ♂; 95, pygidium, ♂.)

Nysson distinctus Fox; Ent. News, II, 31; 1891. ♂ ♀.
Bothynostethus distinctus Fox; Proc. Acad. Nat. Sci. Phil., 551; 1893. ♀ ♂.

Two ♂ ♂ of this shining black wasp were taken in Logan county, end of June, 1910. They are 5.50 mm. long. The insect seems quite variable, both the venation and the margin of the clypeus differing in the two Kansas specimens. The venation as illustrated in figure 17 does

not quite agree with that as given in Fox's diagnosis of the genus. The peculiarly and strongly sculptured propodeum should serve to distinguish *distinctus*.

The insect is well distributed in the United States.

RECAPITULATION AND COMMENT.

The Larridæ of Kansas number fifty-eight species, which are included in ten genera. All but two of these species have been taken within the state by the Biological Survey of Kansas University, between the years 1875 and 1913.

The following table shows what proportion of the Larridæ of the United States, as represented by the ten genera, is possessed by Kansas. The varieties are omitted here.

Genus.	Number of species. U. S. Larridæ.	Kansas Larridæ.
1. Larra	1	1
2. Notogonia	3	1
3. Larropsis	21	12
4. Tachytes	31	12
5. Tachysphex	69	22
6. Lyroda	2	2
7. Plenoculus	12	2
8. Niteliopsis	13	4
9. Miscophus	2	1
10. Bothynostethus	1	1
Total	155	58

The above enumeration may be a little underestimated. It is possible that a few species (under these ten genera) have been omitted. There is no doubt, however, that inasmuch as in many instances species are described from one sex only, or by comparing the insect with the descriptions only instead of with known or related species, the list is not free from synonyms. As far as undescribed material goes, there is a good deal of such in various collections in the country. There are a few genera of Larridæ in this country, such as *Miscophinus* and *Pisonopis*, which have not as yet been reported from this state; these represent comparatively few species, however, and should, even with their addition, still maintain the total number of species for the United States below the 200 mark.

Of the Kansas species, thirteen are described here as new. Of these nine belong to the genus *Tachysphex*, two to *Larropsis*, and one each to the genus *Plenoculus* and *Niteliopsis*.

Miscophus and *Plenoculus* are now reported from Kansas for the first time.

The Larridæ of the genus *Tachytes* include our largest and most bee-like species. *Tachysphex*, though by far the best represented of the genera, is made up of rather inconspicuous wasps which can be secured in variety only by dint of close collecting. Genera such as *Niteliopsis*, *Plenoculus* and *Miscophus* are composed of small forms; it is by reason of this diminutive size, their activity, as well as special habitat, that many more species will eventually be discovered.

The Larridæ of the United States range from 3 mm. to about 23 mm. in length.

The ocelli or simple eyes present characters of first importance within the family; the mandibles perhaps stand next in order; which is the case because these two organs are similar or nearly so in both sexes. Venation, while of great importance within the family, is often variable, particularly in the smaller forms. Considered on a broad basis, the above characters may be said to be of supergeneric value.* The more relative form and position of the ocelli, the variation in the mandibles, legs, venation, pygidium, eighth ventral segment (♂), the convergence or divergence of the compound eyes, are commonly of generic importance. The often pronounced sexual differences, found, for example, in the antennæ, pygidium, armature of legs, and the clypeal outline, are of generic and specific value. It is owing to these marked structural as well as color differences, and to the frequent absence (apparent or real) of good characters common to both sexes, that renders impracticable, in those genera containing a goodly number of species, the construction of one specific key to include both sexes. Very important specific characters are: The character of the anterior margin of the clypeus; the width of the interocular space at the vertex; the distinctness, shape, armature and punctures of the pygidium; the comparative length of the antennæ and their joints, as well as the form of any of the latter; the sculpture of the head, thorax and propodeum (closeness and size of the punctures, striations, granulation, etc.), and the color. The latter, while remarkably constant in some groups, is quite variable in others, and should therefore be used with care.

* There may prove to be characters even more far-reaching than those just mentioned (and as suggested by certain writers) to be found in the sternal region of the thorax. The mouth parts, which for their proper study would require careful and tedious dissections, could possibly furnish clews as regards the status of the Larridæ.

The Larridæ are accorded different values by different authors. By some they are treated as a family; by others they are given subfamily rank. All are not agreed upon what genera should be included and what excluded from the group. While this state of things may in part be the resultant of insufficient study and faulty interpretation, it can also follow from the continuity of Nature, in that it does not always permit of well-defined divisions to be made in its realm.

PART III.

Studies on the Biology of the Kansas Larridæ.

The very general and fragmentary nature of our knowledge concerning the habits of the North American Larridæ has induced the author to publish the results of his observations on this group of insects. These studies are quite incomplete, since they embrace but a small proportion of the Kansas species, and treat almost solely of the habits of the adults, for while the actions of the latter were in many cases observed in detail, the early stages have been practically neglected.

The entomological division of the Biological Survey of the University of Kansas made collections in the northwestern portion of the state during the summer of 1910, in the southwestern area in 1911, and in the north central part in 1912. Not very much attention was given the Larridæ during the first of these surveys; in 1911, however (when the writer decided to monograph the Kansas forms), the habits of several species were studied in detail and a large series of the insects secured, while during the ensuing year I was enabled to make numerous additional observations.

Ever alert and watchful in the hot sunshine, the Larridæ are among the swiftest of insects, and readily evade any incautious attempt on the part of the collecter to secure them; on cool, cloudy days they are quite sluggish, and certain species, largely males, may then be taken on various flower heads. In the western portion of the state, species, mostly of the genus *Tachytes* and *Larropsis*, appeared to favor the blossoms of snow-on-the-mountain (*Euphorbia marginata*) and stinking clover (*Cleome serrulata*), both of which occurred in large patches, while the Russian thistle (*Salsola*) and a small prostrate species of *Euphorbia*, found in sandy situations, proved attractive to others. The latter plant was found to harbor the smaller Larridæ, such as those of the genera *Tachysphex*, *Niteliopsis*, and *Plenoculus*.

Many of the Larridæ, particularly of the genus *Tachytes*, which contain some of our larger forms, produce, when on the wing, a high-pitched buzz, sufficiently characteristic in a few

species to enable the listener to distinguish between them. Thus *Tachytes mandibularis* has a higher-keyed hum than the larger *T. distinctus*. The hum of these wasps is therefore of great assistance to the observer who is desirous of seeing them hunting their orthopterous prey; for whereas the wasp is often lost to view while flying among the weeds, her audible buzz enables one to follow her with some degree of certainty.

Some, notably *Tachytes*, commonly fly quite far from their burrows in search of their prey, while many of the *Tachysphex*, having shorter wings but longer legs than the species of the foregoing genus, are largely cursorial, and seek their victims at no great distance from their tunnels, and, since these wasps seldom move far in a straight line, their course will often bring them again before their nests.

PREY.

The prey of the Larridæ consists very largely of orthopterous and hemipterous insects. These wasps are therefore of some economic importance. Where the insect attacked is an orthopteron, it may frequently be far larger than its aggressor (fig. 112), and is then able to offer it stout resistance before being subdued, and not infrequently escapes altogether. In other cases the fated victim is no match for the wasp, which, clasping it with its legs, readily administers the fatal sting under the thorax.

As a consequence of an older and more peopled country, the Larridæ, in common with many other groups of insects, have been better studied in Europe than in America. In the former country, Fabre observed *Tachytes obsoletus* provisioning its nest with the larva of Œdipoda. *T. tarsina* captures a larval acridian, while *T. pompiliformis* seems to furnish her progeny with a more diversified menu, having been seen by different entomologists to capture lepidopterous larvæ, as well as Orthoptera of the families Acridiidæ and Gryllidæ. Sharp (Camb. Nat. Hist. Ins., pt. 2, p. 117; 1901) speaks of "a species of *Tachytes* in the south of France," which selects as its prey one of the ferocious Mantidæ, stinging this capable insect, at an available opportunity, in the "nerve center between the formidable arms; . . . subsequently the *Tachytes* paralyzes each of the other pair of legs, and then carries off its victim." *Larra anathema*, a large and powerful species of the Old World, provisions its nest with mole-crickets. The

small wasps of the genus *Miscophus* have been noted to prey on spiders; this also holds true of our species in this genus, so far as observed.

The writer has had access to but a small portion of the European literature relating to fossorial wasps.

In America, *Tachytes harpax* and *mandibularis* use Locustidæ of the genus *Xiphidium.* Acridiidæ furnish the prey of the other species of the genus, in so far as it was noted. The *Tachysphex* were observed to seek Acridiidæ, which may be of the subfamilies Acridiinæ, Tryxalinæ, or Œdipodinæ. An *Iachysphex hitei* Roh., in the collection of the U. S. National Museum, was captured with a young cursorial mantid, *Litaneutria minor* Scudd. An interesting observation has been made in Texas by Hartman, who took *Tachysphex texana* in the act of capturing a fly larger than herself. (See Bull. 65, Scientific Series, U. of Tex., p. 55-6; 1905.) The other genera of Larridæ furnished, on the whole, rather fragmentary data as regards their prey. In the case of *Notogonia argentata,* young Gryllidæ are used; some of the *Larropsis* prey upon *Ceutophili* (Locustidæ), while *Plenoculus* and several of the *Niteliopsis* store their nests with small Heteroptera. It is to be noted that the prey of some certain one of these wasps is frequently limited only to a family of insects, and that therefore these "fossorials" are not as select as regards their victims as is often held to be the case.

Nests.

According to my observations, the Larridæ almost invariably excavate their own burrows. On rare occasions they were found to have taken advantage of a crack, and perhaps also of a strange tunnel, to lessen the work of digging. A few of the smaller species make their nests in brambles, but the great majority burrow in the earth. *Tachysphex* digs shallow one-celled tunnels, and must often make several in one day. *Tachytes* and *Notogonia* make far more elaborate burrows, which are deeper and contain from a few to many cells. Supplying such nests as these requires several days, and in certain cases perhaps as much as eight or ten. The very incomplete observations on the genera *Larra, Larropsis, Plenoculus* and *Lyroda* seem to indicate that their nests are neither dug nor provisioned in a single day.

Oviposition.

Except in the case of *Miscophus*, the egg of the Larridæ is placed transversely, or nearly so, across the base of the prothorax of the orthopteron or hemipter, as the case may be, and is securely fastened at its cephalic end in the soft membrane, behind* and a little inside of one of the fore coxæ. It may be well to mention here that *Priononyx,* one of the Sphecidæ which preys on Orthoptera, glues her egg on the membrane at the exterior base of one of the *hind* coxæ, the egg lying along the base of the posterior femur, instead of across the thorax, as in the first case. In either case, however, it is well protected by its position from any movement which the often sprightly entombed victim may make. According to Ferton (Actes de la Soc. Lineenne de Bordeau, xlviii, 266-8; 1895), the egg of *Miscophus bicolor* is secured to the anterior face of the spider's abdomen, and is vertical in position.

The Larridæ do not display as much specialization in nidification, perhaps, as do many of the Sphecidæ, and far less than is exhibited in the Eumenidæ. They are, however, persevering workers, and at times show much valor (if such it may be called) in attacking their often huge prey.

Habits of the Males.

The foregoing remarks apply solely to the female Larridæ, for seldom, if ever, do the males assist in the work of nidification, and, not being furnished with a sting, are wholly incapable of subduing such an insect as is overcome by the female.

While it is true, generally speaking, that the males are seen more frequently than the other sex, the explanation of this may be found in the habits of the former. They are often found at flowers, or resting on a tree trunk, whence they make frequent sallies at passing insects, much in the same manner as some of the more pugnacious butterflies. The above applies largely to the genus *Tachytes.*

A few *Larropsis* males can be taken at flowers; it is likely, however, that they occur in greater numbers in the vicinity of holes made by various animals, such as rabbits, gophers, and badgers. In the walls at the entrance of such burrows numer-

* The Peckhams (Wasps Social and Solitary, p. 263; 1905) speak of a *Tachysphex* (*Larra*) *quebecensis* storing her nest with several little grasshoppers and laying the egg *in front* of the first pair of legs. C. M. Weed, in his Life Histories of American Insects, p. 150, fig. 55, shows a young tryxaline locust with a *Tachysphex* egg placed behind the fore coxæ.

ous small galleries may be found, and these are frequently entered and enlarged by such *Larropsis* as *ater* and *bruneri*. It is certain that some of these holes are made by the male insects, probably as a place of retirement during unfavorable weather and at night. A black species of *Tachysphex*, probably *fusus* or *terminatus*, was observed digging a hole in the sand during the hot afternoon hours, closing its retreat from within. *Plenoculus apicalis* and *Niteliopsis affinis* have much the same habits as the above.

Enemies of the Larridæ.

Among the enemies of the adult wasps may be mentioned: Asilidæ, or robber flies, which are very abundant on the Great Plains, and which capture the largest Larridæ; various species of ants, which, roaming everywhere, have been seen to cause considerable annoyance to the wasp as she was digging, and at times they took possession of her prey; lizards are probably a source of minor hazard, in that they give chase to the wasp while dragging her heavy load over the ground. Small tachina flies destroy large numbers of wasps by appropriating the food of the hymenopteron for their own young.

Stinging and Malaxation.

It would appear that the Larridæ, and probably numerous other wasps as well, sting their victims not primarily for the purpose of giving them their quietus, so that their offspring may feed with safety thereon, but in order that the wasp herself may successfully manipulate her prey, and suffer the least inconvenience, delay or injury thereby. When a little *Tachysphex*, for example, attacks an acridian far larger than herself, or the sphecid *Priononyx* pounces upon a large *Melanoplus* or *Mermiria*, as often happens, it would seem logical that in the violent struggle which ensues that the wasp seeks to overcome her prospective victim as speedily as possible. The more time employed in this rough occupation, the greater the opportunity for the grasshopper's escape, and so the wasp endeavors to quiet it with a well-directed sting under the thorax, presumably penetrating one of the large ganglia of that region. Usually, if not always, one or more subsequent stings are given, these, perhaps, with a view to the welfare of the young. But it must be confessed that some of the entombed victims may become exceedingly lively if taken out and disturbed, though they seem to have lost the sense of direction and co-

ordinate action. Again, I have found fresh as well as putrefying Orthoptera in a single closed cell, showing that the wasps administer their stings with varying degrees of certainty, sometimes with the effect of killing, at other times only paralyzing. Furthermore, the egg is placed in such a secure position that it can not be readily if at all dislodged by any movement of the victim, and the larva, on hatching, remains for some time in the same position as the egg.

Malaxation.

A number of species of wasps have been observed by different entomologists to "malaxate" their prey after it has been stung. To malaxate (*malasso*—to knead, to soften), as referred to these insects, consists in that process of biting or chewing at their victims for a purpose which, to my knowledge, has not been satisfactorily explained. The procedure has been carefully observed by Marchal, in Europe, who considers it very important. He noted it in the case of the philanthid wasp *Cerceris ornata,* which pricks and squeezes the neck of the bee *Halictus,* licking off the juice which exudes. In this case malaxation was found to quiet the victim more than if merely stung, having therefore a tendency to shorten its life.

I have seen *Notogonia* and *Tachysphex* and *Tachytes* bite the prosternum of their prey, going as far as the mouth of the prostrate insect. In one case the wasp remained with its distended jaws applied the orthopteron's neck, suggesting, perhaps, that she was lapping up a liquid. Ferton is of the opinion that *Miscophus* malaxates her spider prey to obtain such a fluid. It is doubtful, however, if the wasp's jaws are always sufficiently powerful to draw out any nourishment in that manner. Malaxation, as the Peckhams have observed, is not done in every case. It would seem, therefore, to be secondary in importance to the act of stinging, and appears to be of doubtful purpose.

HABITS OF THE SPECIES.

Typical Larridæ, or Larrinæ.

(With only one perfect ocellus.)

Larra americana Cresson.

The above insect, as far as I can ascertain, is the same as *Larra analis*, our large shining species. Hartman (Bull. Univ. of Tex., No. 65, pp. 61-62; 1905) has found *americana* provisioning its several-celled burrow with crickets. The wasp has a peculiar way, we are informed, of digging her nest, backing out and using her head and fore legs as a kind of scraper. The insect is rare in Kansas, where nothing was observed of its habits.

Notogonia argentata Bve. (Fig. 118, egg *in situ*.)

This rather long-legged wasp was studied on the University campus, at Lawrence, at the end of August, 1911. Considerable time was spent in locating the burrow, but the first insects observed gave me no results aside from noting that, from their habit of investigating holes and crannies, the prey should probably be one of the Gryllidæ. This surmise was soon verified when at 2 P. M. September 2 a *Notogonia* was seen flying about the stone steps of the Museum building, carrying under her body a young *Gryllus* about the size of an ordinary *Nemobius* cricket. She let go her prey at my approach, but soon grabbed it again by the base of the antennæ, and, taking wing, flew about the steps and cement walk in a rather undecided manner. She appeared either to have lost her nest or to be searching for one, for she fussed around for fifteen minutes, never letting go of her burden the while, attempting at times to enter cracks which were not sufficiently spacious to admit both cricket and wasp at one time. Finally, at 2:15 P. M., she dropped the *Gryllus* and entered the crack, but on coming out after a stay of half an hour the orthopteron was totally ignored. At about this time another wasp of the species was flying about near by. She would alight, pick up a pebble in her mandibles, to drop it again, having to all appearances no definite aim. At 3:10 P. M. a third *Notogonia* was seen to fly heavily with a cricket about as large as herself, alight near a crack in the cement walk, and run into this crevice with her prey beneath her. This being forbidden ground for the knife and trowel, I searched the earthy slopes along a very small stream which flowed through the golf links near by.

Here, on September 4, I located what seemed to be a small settlement of these wasps, the males being the ones more commonly seen. At 2:45 A. M. I watched a *Notogonia* hunting about the grass near a bank of loose earth. On the whole, her movements were not as quick as those of *Tachysphex*, excepting, perhaps, when she shifted her hunting grounds by a rapid little flight. Now and then she would stop and pry under the dead and flattened grass, with the effect, at 2:45 P. M., of arousing a young *Gryllus*. The latter, by means of continued and vigorous hopping, made good its escape, her enemy searching about excitedly in the meantime. At a favorable opportunity I caught the fugitive and let it fall near the wasp. She pounced upon it like lightning, and stung it immediately, apparently under the thorax. After cleaning herself, as usual, with her fore legs, she seized her prey, and, turning it over on its dorsum, chewed at its soft neck. This operation completed, the young *Gryllus* was placed on its venter again, and, *Notogonia* striding it, seized it by the base of the antennæ, and, by a series of runs and short jumps, with an occasional rest, she carried her booty in a good straight line for a distance of thirty feet, to run at 3:03 P. M. into a hole in the bank. The opening was somewhat concealed, and was placed at about two vertical feet below the grassy area. There was no soil heap before it, as in the case of the tunnels of *Tachysphex*, and it seemed probable (after digging out the gallery) that it had been only partly excavated by the wasp in question. *Notogonia* remained within for a minute or two, coming out to walk in the vicinity for a longer period. Reentering at about 3:09, she did not appear until 3:30. She was probably working on a cell during the interval, for at 4:05 she was biting out small lumps of earth at a distance of two or three inches from the hole. Working thus for a short time, she entered, to remain within until 5:10, when she emerged, seized a little stick in her jaws and brought it in her burrow. At 5:25 she was still inside, and probably passed the night in that security.

At 9 A. M. the next morning I saw her enter her burrow, and at 9:30 she was hunting in various holes and about grass clumps, four or five feet from the nest. At 9:35 she attacked a small *Gryllus*, which leaped valiantly, but this time to no

avail, for it was soon rendered helpless by a sting under the thorax. It was malaxated on the ventral side of the neck, as in the first instance, and carried venter down. The wasp made little runs and short flying jumps from grass blades with her burden, and though very near her burrow, took considerable time in locating the same, which she entered at 9:40. Five minutes later she came out, and after a short pause took wing, but returned unnoticed. At 10:08 she was very busy filling up her tunnel, working rapidly, gathering little lumps of earth and other material, such as twigs, thorns, and Orthoptera excrement. This material, though varied in character, was selected with some care, and at first brought in from some little distance. Her first trips averaged a little more than two per minute; her final ones (which were made mostly on the wing), from six to seven per minute. Shen then remained inside for a little more than twenty minutes. As the burrow became filled her trips for material were more hurried and shorter, and instead of picking up loose earth she would frequently bite off a piece, for a time, from two separate places a few inches away. At 11:18 her burrow was so shallow that when she entered she could be seen within depositing her load, occasionally emitting a squeaky little buzz. She seemed to become rather excited as her work neared completion, being then somewhat easily frightened, and at a movement from the observer would turn about and regard him doubtfully, as it were. She frequently carried lumps of earth of at least her own weight. None of this material is tamped down, but lightly placed at the bottom of the tunnel. The *Ammophilas* and *Isodontias* among the Sphecidæ, and many of the larrids, pack the soil, at least when their burrows are nearly filled. At 11:35 A. M. *Notogonia,* having finished the work of filling the burrow and disguising the site, flew away. The location of the tunnel was thus fairly well hidden, largely by excrement; in addition there were a few twigs and some soil. Its diameter at the entrance was one-half inch high by nine-sixteenths of an inch wide. The earth packing extended only for an inch or two below the surface. The shaft, at first subhorizontal and widened in an irregular manner, soon narrowed and sloped quite steeply. I soon lost the main tunnel, but upon digging deeper found three neat shafts, each terminating in a rounded cell. The first of the latter was at a depth of about five inches

and seven from the mouth of the main tunnel. It contained an immature *Gryllus*, with the smooth, shining, whitish *Notogonia* egg transversely arranged on the prosternum (fig. 118, *E*). The second cell was similarly provisioned, while the third yielded two crickets, one of which was quite small. One of the victims from this nest was decidedly active when touched, though its leaps were neither continued nor well directed. Digging still deeper revealed no further cells.

There are several things worthy of note regarding the habits of this insect. Although not seen in the act of excavating her burrow, she never used her feet in filling up the hole, as is done by *Tachysphex*. The latter insect, however, has the long-fringed fore tibiæ and tarsi, admirably adapted for digging in the loose, sandy soil (see fig. 81), while the heavy black earth in which *Notogonia* was working did not very readily permit digging with the feet, which in this case are not long-fringed (fig. 80). The immature *Gryllus* used were so young (or of a different species) as to be pallid beneath; darker, slightly larger *Gryllus*, as well as mature *Nemobius*, were scarcely noticed when thrown down before the very nose, so to speak, of the hunting wasp.

Ashmead (*Psyche*, p. 63; April, 1894) says: "In the south I have seen *Larra argentata* provision its cells with a small, immature cricket, which it completely paralyzes before storing it away in its clay cell. From a single cell I have taken as many as six of these small crickets."

Larropsis divisa Patton.

The females of the species of *Larropsis* were not found to be numerous in any locality, and consequently the method of searching their prey was seldom noted. At Leoti, Wichita county, August 19, 1910, at 8:53 A. M., one of these active insects was seen to enter its nest, which was situated at the upper edge of an old brick-clay pit, largely choked with Russian thistle. The entrance to the tunnel was by no means neat, and the insect had taken advantage of a small horizontal crack in the earth, as if to lessen the labor of excavation. *Larropsis* flew with her burden, which was evidently an immature *Ceutophilus* (Locustidæ, but rested several times *en route*, carrying the "cave" cricket well forward beneath her. Thus she entered the hole, very soon to reappear and take wing. Other *Ceutophili* were brought in at 9:06, 9:15, 9:35, 11:03 A. M., and 1:10

and 1:42 P. M. She returned empty handed at least twice between these hours, and sometimes remained a considerable time within her burrow.

An attempt to follow the tunnel failed. I should judge, however, that the affair was of good depth and several-celled. The wasp herself not being captured, her identity is uncertain, for besides *divisa*, the similarly colored but larger *aurantia* was taken in the same pit. At Kirwin, Phillips county, in August, 1912, however, the former species was seen to enter a hole the size of that made by a mouse. She reappeared very shortly, carrying a small *Ceutophilus* under her. Fearing to lose this wasp, she was captured.

The fact that at least some of the wasps of this genus occur very frequently about holes dug by animals would perhaps indicate that the "cave" cricket is the common food of more than one species. These Orthoptera fairly swarm in such retreats during the day, where they can often be seen congregated in numbers along the sides and ceiling. It is not improbable that the wasps commonly nest in the vicinity of some such hole, and that the lack of marked pilosity of the species of the genus *Larropsis* may be partly accounted for by their habits.

TACHYTES.

In comparison with the members of the genus *Tachysphex*, the actions of these wasps are slow. They do not run over the ground in such mad haste as do their smaller relatives, and excavate their burrows in a more dignified manner, pushing out the soil with the abdomen instead of throwing it out behind them in a stream like the *Tachysphex*.

Tachytes abdominalis Say.

My notes on this species are very fragmentary. The insect was not infrequently seen hunting her prey in moist places where immature Tettigidæ (grouse locusts) appeared to be the common object of pursuit; she was also seen in stubble fields, where she captured young *Melanopli*. The wasp moved rather slowly and often appeared to experience some difficulty in stinging her prey, due perhaps to the small size of the latter. I located a single nest of this species in Trego county, July, 1912, but failed to trace the tunnel for more than five inches, for which length it was approximately vertical.

Tachytes distinctus Sm. (Figs. 113-116, early stages and nest-mound.)

It was not until the summer of 1912 that I was able to locate the burrow of this large and common species. Many times had I watched her hunting her prey among the weeds, while on several occasions she was seen to pounce upon the immature acridian, but here my observations were ended, for *distinctus*, holding the locust beneath her,* would fly away and be soon lost to view. At times she would rise high in air with her burden before starting in the direction of her burrow, and again she would pursue her journey homewards at an elevation of only a few feet over the weeds. Her mode of hunting also was not uniform, for where one female would crawl over the vegetation, another examined the weeds while on the wing. Perhaps the latter mode is the more common in the species, and was well exemplified by a *distinctus*, which was seen inspecting a large patch of stinking clover (*Cleome*) for her orthopterous prey. The locusts on these weeds did not relish the presence of their fierce foe, and would oftentimes hasten behind a stem for shelter. Passing from plant to plant, however, she finally selected a good-sized *Melanoplus* nymph, poised briefly before her intended victim, and, pouncing upon it, dispatched it with her sting.

In Rooks county, northern Kansas, these wasps were abundant, and here several of their burrows were located. One morning, in early August, a *distinctus* was seen to fly with a heavy acridian to a hole in a sandy slope, and enter it with her burden beneath her. At this juncture I left the spot and did not return until 4 P. M. A short period after this hour *distinctus* came flying heavily, carrying beneath her a good-sized locust, venter up. She alighted heavily once or twice in the bush near by before entering her abode. Stopping up the entrance, I commenced digging with my trowel. The soil was rather loose and sandy, and moist to a depth of about six inches, where it was replaced by firm, black earth, and finally by a hard, dry stratum. The circular entrance to the wasp's tunnel was six-sixteenths of an inch in diameter and went through a heap of sand one and one-sixth inches high by two and fifteen-sixteenths inches wide at the base. The outer covering of this mound was composed of small, loose lumps, per-

* It may be said here that the wasp is quite particular as regards the method of carrying her prey. She sometimes fusses considerably before grasping it in the right manner, *i. e.*, holding the orthopteron's antennæ in her jaws and clasping the body beneath her with her legs.

haps recently thrown out of the nest; under this the soil was firmer, as though rain-packed. The whole affair had somewhat the appearance of a mud tube, such as are made by crayfish. The hillock is illustrated in figure 116. *Tachytes mandibularis* is reported by W. H. Patton to make similar tubes. I had not dug long before a confined, squeaky buzz was heard, and soon the proprietor was brought to light from a hole fully ten inches below the surface of the ground and fourteen inches from the entrance. The latter I followed, and found it to slant at an angle of about 60 degrees, the tunnel being lost before I reached any of the cells. About two inches beyond the wasp lay two nymphs of a species of *Melanoplus*. One of these had the long, curved *Tachytes* egg (fig. 113) transversely placed on the prosternum, its cephalic end secured in the membrane behind and somewhat inside of the base of one of the fore coxæ. I dug carefully for nearly two hours, during which time twenty cells and fifty-six acridians were found. The main shaft of the nest was soon lost, but the cells appeared strung along its length in a rather irregular manner. With the exception of the one in which the wasp was found, they were closed with earth. They were rather small and often very close to one another. The locusts were distributed in these chambers as follows:

2	cells	contained	1	acridian each.
4	cells	contained	2	acridians each.
10	cells	contained	3	acridians each.
4	cells	contained	4	acridians each.
20			56	

Fifty-one of the victims belonged to the tribe *Melanopli*, and of these only one was mature; the five remaining insects were small species of full-grown Tryxalinæ, viz.: four *Ageneotettix deorum* and one *Orphuella* near *speciosa*.

A few of the locusts moved their antennæ in a feeble manner, while with fresh specimens could be found others darkened and well on the road to decomposition. The cells were penetrable by a heavy rain, and in nearly every case contained a *Tachytes* egg or larva. Some of the latter were of good size; one seemed about two-thirds grown. The larvæ usually lay in a curve over their food. The freshly hatched specimens appeared much like the egg, in being of rather uniform thickness and showing very little indication of any segmentation. The largest larva, however, had deep intersegmental incisions,

a stout form, and some mammæ-like processes on the thoracic region (fig. 114). Some of the grubs showed a reddish hue through the thin skin, while several were quite green, the color being probably dependent upon that of the juice of the victim.

Two other nests of *distinctus* were located. One of these was but a few feet removed from the one just considered. There was no cone of soil surrounding the aperture as in the first case, but only a little heap of sand before it. The slope was about 40 degrees, and the tunnel seemed blocked for a distance of two and one-half inches down. Sixteen cells, containing in all thirty-eight locusts, were found. From one to five (usually two or three) were placed in each cell. The locusts were of the genera *Hesperotettix* and *Melanoplus*; one of the latter, a male *femur-rubrum*, was mature. The wasp, which I presently caught, was an old one, with noticeably frayed wings and the end of her abdomen coated with dried mud. Nest-building, however, had not progressed as much here as in the first case.

Shorty before 5 P. M. one evening a female *distinctus* was observed flying about an open area which was carpeted largely with buffalo grass. She would alight now and then to creep among the stems and roots, where she sometimes disappeared from view. At 4:55 P. M. she entered what seemed to be the commencement of a small hole, and began digging with a rather slow movement, emitting now and then the squeaky buzz common to these and many other Hymenoptera. In working she loosens the soil with her jaws, pushes it by with her fore legs, and finally shoves the earth outside with the end of her abdomen (this explains the frequently mud-covered pygidium), but never comes outside the hole with a load of dirt, as do some of the *Tachysphex*. Finally, at 5:23 P. M., she emerged, took wing, and with ever-widening circles disappeared. There was quite a heap of soil around the hole by this time, and much more by 8:35 the next morning, showing that *Tachytes* had done considerable excavating during the interval. I watched her bring in a small *Melanopli* at 8:43 A. M. At 11:53 I found the aperture blocked with soil, the wasp being at work within. On returning at 1:30 P. M. the hole was again open, and at 1:42, 1:52 and 2:17 I saw her bring in *Melanopli* nymphs, the hole being barely large enough to admit wasp and prey simultaneously. She then remained

inside for nearly an hour, perhaps making or closing a cell the while. I did not see her during the next two days. She probably met her death or deserted her nest, which contained but three cells. The soil here was of a rather hard nature; in consequence the tunnel was comparatively short. The first cell was five inches below the surface and five inches to one side of the entrance; the remaining two were not far removed from the first. The nest contained eight locusts (some of which were becoming quite moldy) and some small *distinctus* larvæ.

Tachytes distinctus must be ranked among the beneficial insects, preying as she does upon those most destructive Orthoptera which, though outnumbering these wasps very greatly, are checked to a degree by the combined forces of foes.

Tachytes fulviventris Cress.

This wasp was seen to store its nest with full-grown *Alpha crenulata* (Tryxalinæ), a small and rather fragile insect common on the high and dry plains of Kansas. The nesting habits were observed near the town of Meade, in the county of the same name. Here on June 10, 1911, a small colony of bright, fresh specimens was located. Their burrows were made in the mouth of a deserted prairie-dog hole, which was situated at the edge of a clearing surrounding the mound-nest of the agricultural ant (*Pogonomyrmex occidentalis*).

At 10:40 A.M. I noticed one of these wasps carrying her prey, venter down, beneath her, fly swiftly and directly to her tunnel, which she entered head first with her burden. The wasp held the base of the antennæ in her mandibles and clasped the locust's body with her legs. At 10:42, 10:44 and 10:48 A. M. other *Alpha* were brought in, probably by more than one *Tachytes*. In watching these several wasps a little variation in behavior was noticed. One wasp alighted near the burrow with her load before entering; another paused not at all, but flew to her nest with a high-pitched buzz and rushed in directly. Again one was seen to carry her burden on its side; the bearer in this case experienced some difficulty in finding the exact location of its burrow. While keeping a firm hold on the tryxalid, she flew about a small area and alighted once or twice before finding her abode.

Not being able to keep watch on this colony that afternoon, nor during the next day, the spot was revisited on July 12 (a

cloudy day), when three of these wasps were dug out of steeply inclined holes several inches in length. Two cells, seemingly the terminations of separate tunnels, were brought to light. The first contained four *Alpha* and one small wasp larva; the other cell revealed at least two *Alpha* and five fly maggots, somewhat larger than those of the common house fly. These soon pupated, but never produced adults. It is not improbable that the burrows of these wasps are several-celled when completed.

Tachytes mandibularis Patton.

This handsome species, with its decided buzz, was observed but once in capturing her prey. This was in the Saline river valley. The wasp was flying low over the weeds, resting now and then, examining plants, scrutinizing some with more care than others. Had it not been for her buzzing I would have soon lost her in her rapid flight. She finally pounced upon an immature locustid of green color, probably a species of *Orchelimum.*

Young Locustidæ being far less numerous than immature *Melanopli, Tachytes mandibularis* would usually have a more protracted hunt for her prey than her ally *distinctus.* Can the more sustained flights from plant to plant in the former species explain the stouter form and probably greater wing power of *mandibularis* over *distinctus*?

The large bembecid wasp *Stizus brevipenne* hunts in a manner quite similar to *mandibularis,* examining the stems of *Helianthus,* etc., as she flies and finally finds her prey, a large *Xiphidium.*

Tachytes obductus Fox.

This apparently rare little species frequented the muddy sand shores of the south fork of the Solomon river, in Osborne county. Here a few specimens were seen searching for immature Tettigidæ. The wasp runs over the ground at a moderate speed, stopping rather often to clean herself (this probably because of the moist nature of the sand). She was seen to capture her prey on two occasions. The grouse locusts were very small and easily borne away on the wing. No burrows could be located.

Tachytes mergus, also a rare insect and of swifter movements than her golden neighbor, had the same hunting grounds and probably the same prey as *obductus,* since Tettigidæ appeared to be the only suitable victims in the locality.

Tachytes obscurus Cress.

This wasp was taken but once with her prey—a very small acridian.

Tachytes rufofasciatus Cress.

This *Tachytes*, which has much the same appearance as *fulviventris*, was observed in Trego county, near those picturesque chalk cliffs which skirt the sandy bed of the Smoky Hill river. Here on July 13, 1912, several of these insects were watched hunting their prey along the edge of a dense and wide-spreading field of Russian thistle, dragging the victims a short distance over these weeds and then over the adjoining plowed ground to their burrows in the latter. The thistle supported an abundant population of largely immature *Melanopli*.

Early in the morning a *rufofasciatus* was observed flying from plant to plant and running hastily over the thistle tops in quest of her prey. At 8:18 A. M. she caught and stung a locust and dragged it laboriously over the disturbed soil to her nest. At 8:22 she secured another, with which it took her thirteen minutes to reach her burrow. Upon reaching the same she let go her prey, entered, and partly emerging head first, pulled it in by the antennæ. The wasp remained within forty minutes. This time was employed, perhaps, in closing a stored cell or in excavating another. She was off hunting again at 9:18 and five minutes later captured a small *Melanopli* nymph, with which she flew to her abode. This was the only instance in the locality where the smaller size of the victim permitted of its being borne away in flight. *Tachytes* was off again to the weeds, and at 9:55 pounced upon another *Melanopli* of a green color. She clung strongly to the dorsum of the struggling insect, and, stinging it under the thorax, soon quieted it. After biting (?) it awhile under the thorax she straddled the insect (which lay in an upright position), seized its antennæ near their base in her mandibles, and, holding the acridian as well with her third pair of legs, began her journey. Here she made use of her first two pair of legs and augmented her progress every now and then with a buzz of her wings. While in the weeds the heavily laden insect strives to keep on top of the Russian thistle, whence a leap (which she frequently essays in an effort to make better headway) often brings her only a little distance in advance and far down among the stems. Nothing daunted, however, she struggles to the summit of another plant, perhaps to repeat the performance. Several

other *rufofasciatus* were watched while stinging and transporting their prey. In two cases the latter were mature *Melanoplus* of about the size of a male *femur-rubrum*—heavy burdens indeed for these wasps. The larrids frequently hunted at about the middle height of the thistle, where, though at times lost to view, they could be heard colliding with the plant. In seizing her intended victim she seemed to forget all else, and the pair often fell to the ground during the struggle. The locust once overcome, the wasp does not delay the journey nestwards for long, nor does she always rid herself of the dust incurred during the fray, as many other species of the Larridæ do with great care.

The wasp worked in a rather desultory manner during the later afternoon hours. One, which had the appearance of being very tired, was noticed hunting at five P. M. The day was exceedingly warm, and *rufofasciatus* did not appear to relish the task of dragging her prey over the dry and dusty field, which offered numerous impediments to her progress in the form of a multitude of furrows, loose, shifting soil and other irregularities. Often, indeed, would the tired wasp gain the summit of some small ridge, only to tumble headlong with her prey into the furrow which she had but left. Thus covered with dust, the weary insect would sometimes abandon her prey and fly up in the air in a slow manner. Small parasitic flies sometimes follow these and other wasps in hopes of depositing their young, at a favorable opportunity, upon the captured acridian. Madame Wasp, however, is not always unmindful of the presence of these pests, for once she was seen to make a short dash at the dipteron, and turning again from her work, regard the unwelcome insect.

I attempted to dig out three burrows, but owing to the loose and unstable character of the soil met with no success. There was little or no evidence of a soil heap before the tunnels, which might lead one to infer that the wasp did much tamping and pushing and but little ejecting of the soil. The nests are probably several-celled.

TACHYSPHEX.

These comprise a goodly number of small or rather small wasps, largely cursorial in habits. They are much less pilose than *Tachytes*, and are exceedingly active in their movements.

Tachysphex fusus Fox and *terminatus* Smith.

Though neither of these red-tipped species was rare, little was noted of their habits. A *T. fusus* was taken in the town of Pratt, in southwest Kansas, endeavoring to fly from the cement walk with an immature *Melanoplus*, somewhat larger than herself. In Ness county, another of these wasps, having dug her nest in a nearly vertical bank of earth, stored it with two immature Tryxalinæ. The hole was two and one-half inches long and contained a single cell. *Terminatus*, which is very closely related to *fusus*, seems to have about the same habits as the latter, being taken once with a young tryxalid. A *Tachysphex*, which had the appearance of being either of the above species, was noticed nesting in the sand, in Graham county, August, 1912. She had evidently closed her burrow before going to the hunt, for I arrived in time to see her open it and enter, to reappear immediately to reach for a very small acridian which she had deposited before the hole. This orthopteron completed the store of provender, for she commenced filling up the burrow. At this juncture a small velvet ant (*Mutilla*) was attracted to the scene of operations, and lingered about the nest. *Tachysphex* did not appreciate the visitor, for she would approach this hard-shelled insect, and to all appearances try to bite it. When the latter ventured to enter her partly filled tunnel she would assist *Mutilla* in no gentle manner to make her exit therefrom. The hole was at length filled without accident, and, smoothing over the site, the wasp took wing. The tunnel was the usual short affair of the genus *Tachysphex*, its single cell containing several acridians of very small size.

Tachysphex plenoculiformis Williams.

It was early one hot July afternoon in 1911, in barren Haskell county, that this rather diminutive new species was seen to alight on the sandy soil, holding under her body a very young tryxalid locust. Thus burdened she ran into a hole near a small plant of Russian thistle. She did not tarry inside, but was out in a minute or two, and after circling about a little flew afield. At 1:41 P. M. she returned, to all appearances empty-handed, but decidedly immature tryxalids were brought in on the wing at 1:47, 1:51, 1:58 and 2:08 P. M. In every case but one (when she released her burden to rest for a short time) she flew directly to the tunnel with her prey. At 2:13 she commenced to fill the burrow from within, backing

in, and at the same time directing a load of sand inside. Now and then she interrupted her labors by flying to an adjoining weed and resting thereon for a very short time. When her work had the appearance of being nearly done she was captured and the nest dug out. The latter was about one and four-fifths inches long and one and two-thirds inches deep, and the rather enlarged terminus contained six young locusts, which exhibited signs of life by a very slight movement of their legs and antennæ. No egg was found, though it may well have been lost when I dug out the tunnel.

This small insect, with its quick flight and jerky motions, is quite difficult to follow, and flies to and from her nest in a manner that defies pursuit.

Tachysphex propinquus Viereck. (Fig. 112, wasp and prey.)

In the hot sandy country which borders the Cimarron river, in southwestern Kansas, this striking species was frequently observed digging her shallow burrow with nervous haste or running over the ground with wonderful agility in search of her prey.

The following notes, taken in Grant county at the end of July, 1911, should serve to illustrate the wasp's habits to a good extent. On July 26 at 10:41 A. M. I saw a little *Tachysphex* running over the sand. Coming upon a mature *Alpha crenulata* (Tryxalinæ) she pounced upon it and subdued it with a sting. At this juncture a small lizard spied the wasp dragging her booty, and hurried toward the pair. The reptile I frightened away, and likewise the *Tachysphex*, which never returned to her prey. Another wasp, however, was found near by, hunting. This was at 10:55 A. M. After a brief search, during which she ran and flew a short distance and explored the patches of short grass with due diligence, she captured and stung to helplessness an *Alpha*, the latter hopping manfully during the struggle. Then *propinquus* went off to one side, where she brushed and cleansed herself and rested for a short time. Then she placed herself astride her prey (which lay on its back), seized it by the base of the antennæ, carried it a short distance, to let go her hold to malaxate (?) her victim, remaining quietly over the latter with her mandibles opened to their full extent and appressed to the *Alpha's* neck, or head, the attitude suggesting that the wasp might be engaged in lapping up a fluid. She soon resumed her journey.

Resting now and then, she proceeded by active little jumps and very quick running and went directly into her hole, burdened as she was. She was soon seen working the soil downwards from inside, backing in and throwing in the dirt simultaneously with her long-fringed fore feet, at times vibrating her whole body longitudinally and swaying it, as described later in *tarsatus*. After working herself almost to the surface she did some leveling, attacking the remainder of the soil heap and directing the dirt toward the now nearly filled tunnel. At short intervals she turned around and looked briefly in the direction she had been throwing the dirt, as if to make sure that her efforts were being applied in the right direction. When she had nearly completed her work she was captured. The tunnel was in good sandy soil and located in a footprint.* The gallery was packed with soil down to the locust, upon which the long, curved egg was placed as usual. But a short time is required to dig the nest, and when she is nearly or quite through with this work she emerges head first, instead of backing out as is done when in the midst of her excavating.

Propinquus is not very select in choosing her prey, for in addition to *Alpha crenulata* as food for the grub, *Ageneotettix deorum, Mestobregma kiowa* and what appeared to be an immature *Opeia* were also captured. Some of these Orthoptera are giants in size in comparison with their captor; the latter frequently has a strenuous time of it in subduing and dragging them to her burrow. The locusts sometimes escape. On one occasion a *Derotmena,* having been startled by one of these wasps, spread out and elevated its bright red wings somewhat as an open fan, the insect thus presenting an unusual if not a startling effect.

The measurements taken of four tunnels are as follows: Length, 2½, 2, 3, and 2¼ inches; depth, 2, 1, 2, and 1½ inches.

Tachysphex tarsatus Say. (Fig. 117, egg.)

Rather extended observations were made on this persevering and industrious little insect. In a certain limited area in Meade county the burrows were scattered somewhat indiscriminately over the ground, and might thus be termed a loose settlement of *tarsatus*. The weeds were rather sparse here, making it easy for the observer to follow the actions of the

* It may be well to state that these wasps, as well as some of the Sphecidæ, seem to realize that the impression made by a foot or hoof affords an easy start in digging where the crust of soil is broken, and accordingly such spots are often selected.

insect. Her mode of procedure consisted in running very rapidly in a rather zigzag fashion (when she much resembled a male Mutillidæ, or velvet ant), with occasional little flying jumps, and more rarely with a lightning-like flight of a few feet, to a new hunting ground, when, as one would be led to believe, she deemed the old one explored or unproductive. The insect, as if mindful of the burden she must carry, does not wander far from her burrow.

One July morning at 9:15 A. M. I watched this little *Tachysphex* hunting. She ran rapidly over the ground, passing by the larger Acridiidæ, which would often lift up their legs in a threatening manner at the wasp's approach. An insect which she deemed unsuitable she would inspect with scarce a pause, but a desirable one she often pursued in flight. Every now and then she would stop and rest for a few seconds. Her powers of vision did not appear to be particularly good, for on occasions she passed within an inch or two of a terrified nymph, which, evidently aware of the nature of the hymenopteron, would leap away at her approach, dodge behind a plant stem, or lift up its defensive legs. This last action was more than a threat, for more than once have I seen a *Tachysphex* repulsed for a time by a well-directed kick from the frantic orthopteron. However, the aggressor would return instantly to the fray if her prospective prey had not already made good its escape.

At 9:27 A. M. the *tarsatus* under consideration, after a brief pursuit, pounced upon a *Melanoplus* nymph, clinging tenaciously to the same as it struggled, and finally quieted it with a sting under the thorax. After a brief pause, during which she cleansed herself and rested, she placed herself astride her heavy victim (which lay on its back), seized it by the base of the antennæ, and, using her first two pairs of legs for running, clasping her prey with the third, proceeded thus at a run, varied with a frequent buzzing hop, to her nest, about twenty feet distant. She overran her destination, however, by four or five feet, but retracing her steps soon located her burrow, placed the locust within, and very shortly after filled up the hole. Then she concealed the site to a fair degree, exhibiting less skill in this than the careful *Ammophila*. Her work was completed at 9:51 A. M., or twenty-four minutes after the capture of her prey.

I dug out this nest. It was a little more than one and one-half inches long and terminated not quite an inch below the surface of the ground. The tunnel was rather loosely packed with soil down to the *Melanoplus*, which lay on its back, quite immovable, its head toward the slightly enlarged end of the tunnel. A long, pale greenish and somewhat curved egg of *Tachysphex* was fastened transversely across the prosternum (fig. 117).

The habits of this specimen typically exemplify those of several other *tarsatus* observed. The tunnel, which is always dug before the hunt begins, is left open while *Tachysphex* is afield. It is of comparatively large bore, slightly inclined, and not more than two inches long. As a rule, a single locust suffices for one wasp grub in this species; I have never seen more than two acridians to one nest. Though more often the prey is one of the *Melanopli* (immature), Œdipodinæ as well as Tryxalinæ are also used. These are frequently placed immediately before the burrow, which the wasp first enters, to reach out again, seize the locust by the antennæ and drag it within. If the prey is quite small, and therefore not sufficient food for the wasp's progeny, two are used, in which case the tunnel may not be spacious enough to admit *Tachysphex* and victim together.

This insect, among others, suffers considerably from the attacks of a very small tachinid fly (*Diptera*), an exceedingly quick and watchful creature, which deposits her own young usually upon the food intended for the larrid grub, and as at least some of the tiny maggots are found, immediately after their deposition, on or near the wasp's egg, the latter is doubtless destroyed. Whilst a *tarsatus* was hunting, this minute dipteron was seen to follow her closely, alighting near by when the wasp rested, or poising directly behind her. The wasp's first search being fruitless, she returned to the burrow empty-handed. This seemed to suit the little fly, however, for she remained near the revealed hole while *Tachysphex* sallied forth again, this time to meet with success. As she was nearing her tunnel, astride her prey, a little fly flew out to meet and follow her. At the hole were two other similar flies, evidently in a state of excitement over the advent of the wasp and prey. The owner, depositing the locust before the entrance, immediately went within. At this juncture one of the tachinids alighted for a second or less on the thorax of the paralyzed victim,

which was quickly pulled into the burrow by the wasp, but here the two remaining flies followed within, and after a very short stay there came out. I examined the orthopteron as soon after this event as possible (probably within two minutes), to discover four very minute fly maggots on and about the larrid's egg.

In the case where *tarsatus* entered her burrow without any pause, carrying her prey beneath her, a fly followed her and did not tarry therein for more than a second or two. Failing on one occasion to viviposit on the orthopteron which *tarsatus* was dragging within her tunnel, the little tachinid balanced herself on the top edge of the hole and dropped one or more maggots directly in front of the opening. The wasp being within at the time, would, perhaps, in filling up her burrow, throw the maggots, along with some sand, towards the locust. It seems doubtful, however, if these larvæ would be able to reach the latter. Rapid as these wasps are, the flies are often able to follow them in their short, lightning-like flights.

In filling up her tunnel *tarsatus* occasionally produced a squeaky little buzz. She gets up on the mound of extracted soil and backs into the hole, throwing the earth therein with her fore feet, coming out now and then to get more soil. When the tunnel was nearly filled it was easy to observe in what manner the wasp works. Throwing in the dirt, she backs in and vibrates or shakes her whole body longitudinally against the latter, thus pounding in the soil with the tip of her abdomen. She would also sway her body from side to side while vibrating, with the evident purpose of embracing all the necessary area in the operation. This process reminds one of a minute steam hammer at work. As soon as *Tachysphex* deems the site of her burrow sufficiently disguised she takes wing, probably to repeat the oft tedious process of providing for her offspring.

Tachysphex texanus Cresson.

This insect, which bears a superficial resemblance to *tarsatus,* was seen but once, in Barton county, carrying her prey, an immature œdipode of very small size.

Atypical Larridæ.

We now come to what may be termed the atypical Larridæ, which differ from the true Larridæ (Larrinæ) in having three perfect ocelli. Less is known of the habits of this group than

of the Larrinæ, just reviewed. In addition to Orthoptera, Hemiptera and spiders are captured by certain of the wasps to be considered.

Lyroda subita Say.

Mr. W. H. Patton (Ent. News, III, p. 90; 1892) says, concerning this species: It "is peculiar for its nonfossorial tarsi, and its method of carrying *Nemobius,* which it catches to feed its young, is interesting. It holds the cricket by clasping the base of the antennæ between its mandibles and clypeus, the minute teeth preventing the antennæ from slipping; this explains the use of the teeth on the clypeus."

The Peckhams (Instincts and Habits of the Solitary Wasps) have observed that this insect uses small crickets to store her rather deep nest, and that she closes her burrow before seeking her prey. That she also feeds her young from day to day is also their belief.

L. subita was seen on a few occasions searching for her prey, traveling at a rather slow gait for a larrid, occasionally entering cracks or shifting her locality by a short swift flight.

Plenoculus apicalis Williams. (Fig. 120, larva *in situ.*)

This active little fellow (about 4.25 mm. long) was not uncommon in Phillips county during the latter part of August, 1912. Here a small sandy hollow in the midst of a sandy pasture furnished a fair supply of *Plenoculus.* The small, mat-like *Euphorbia* plants were quite attractive to the smaller Larridæ, while an occasional *Plenoculus* could now and then be seen running up and down the stalks of sunflower plants, as if engaged in seeking their hemipterous prey. Not far removed from this locality a broad and sandy pathway leading from "bottom land" up to the bluff, and possessed of a good, sunny exposure, was still more productive in this species of larrid, and here I was fortunate in observing a little of their nesting habits.

During the early part of the afternoon of August 31 two female wasps were seen storing their nests with mature as well as immature *Atomoscelis,* probably *seriatus* Reut. (Capsidæ), which they readily carried on the wing. The bugs, which are green and about 3 mm. long, were carried beneath the body of its captor, but just in what manner could not be determined. I watched one of these *Plenoculus* make four trips, bringing in bugs at 1:22, 1:25, 1:34, and 1:40 P. M., the

hole being always left open when the insect was afield. Catching the two wasps, I endeavored to dig out their nests. This proved to be a difficult task, owing to the sandy soil and to a severe shower which came up. The nest aperture was not neat, and the shaft sloping. The latter I soon lost, but a little later succeeded in running across several cells an inch or two beneath the surface, in firm, moist sand, quite warm in the afternoon sun. One of these chambers contained about six bugs, another five, and in all I obtained about thirty-four Hemiptera from this nest. The cells were at least six in number, rather large and well packed with victims, upon one of which was a half-grown wasp larva transversely arranged with its mouth parts in the skin immediately back of one of the fore coxæ.

The Peckhams (Wasps Social and Solitary, p. 95-6) found *Pl. peckhami* building her nest in the stems of raspberry bushes, partitioning its cells with earthen granules, which are later used by the larvæ in forming the case of the cocoon. As many as nine cells were found in one nest of this insect. It provisions the cells with immature bugs of the genus *Pamera* (Lygæidæ).

Niteliopsis inerme Cresson. (Fig. 119, egg *in situ.*)

Although this dusky little insect was not uncommon in certain localities, very little could be ascertained about its habits. Specimens were taken at Rush Center, Rush county, June 19, 1912, flying low and quite swiftly over hard, sparsely vegetated ground. They alighted but rarely. At Hays, Ellis county, about July 18, 1912, I located an *inerme* burrow in a small area of bare clayey soil. When I arrived on the scene of action she had already stored her nest and was filling the same with pellets of earth. With these she at first descended out of sight, but as the hole was being rapidly filled, she was soon exposed to view. She worked with great rapidity, flying to and fro a distance of a foot or less, selecting bits of earth. Fearing to lose her, she was netted before her work was completed.

The tunnel was neat and round, almost vertical, one and one-half inches long, and cohesively silk-lined for about half its length. I suspect its original proprietor must have been a spider. The bottom of the hole was not enlarged into a cell, but perpendicularly filled with five immature green Hemiptera of the family Capsidæ. One of these (fig. 119) had a large,

curved wasp egg transversely arranged and secured at its cephalic end behind the first pair of legs. The curve of this egg conformed rather nicely to the convexity of the bug's venter, and was stouter than the egg of either *Tachytes* or *Tachyspex.*

Niteliopsis fossor, a large species in another division of this genus, has been taken by Mr. Rohwer, of the United States National Museum, with an immature œdipode (Orthoptera). This wasp has not thus far been found in Kansas.

MISCOPHUS Spp.

Nothing on the biology of our native species was observed; more is known of the habits of this genus in Europe.

Saunders (Hymen. Aculeata, p. 84; 1896) tells us that *Miscophus concolor* Dahlb. "provisions its nest with a small, white-bodied spider, which is found commonly on heath (Smith)."

Ferton (Actes de la Soc. Lineenne de Bordeau, XLVIII, 266-8; 1895) has notes relating to several species. *M. gallicus, niger, nicolar* and *bonifasciensis* were observed to store their tunnels (which were quite shallow and excavated in sand) with small spiders. From seven to twelve of the latter, which may belong to several families, were found in one cell of *M. bicolor.* The author informs us that *Miscophus* bears her paralyzed prey in her mandibles, and proceeds with little hops afoot, or with flying leaps. Sometimes she malaxates her prey, without doubt, as Ferton says, for the purpose of extracting a liquid ("pour tirer sans doute une liquid"). The spider may survive in a helpless state for as long as two months, as Ferton has shown. The cocoon is very strong and composed of agglutinized grains of sand.

Hartman, in his Observations on the Habits of Some Solitary Wasps of Texas (Bull. 65, Scientific Series, Univ. of Texas, p. 55-6; 1905) speaks of a *Miscophus* preying upon "young epeirids of convenient size. These are carried on the wing or afoot, depending on the weight of the victims. To quote this author: "This wasp grasps the paralyzed spider with her mandibles by two or more of its legs, slings it on her back and marches off with it, walking forward, the spider hanging rather to one side in an uncomfortable and rather awkward-looking manner." The nest is very small, one-celled, and, as in the European species, is closed while the owner is away.

SUMMARY.

The Larridæ are very active insects; on the whole, more partial to sandy situations than to those having rich heavy soil. They are therefore more abundant in western than in eastern Kansas.

The males are frequently seen on flowers or basking in the sun. They were only observed to work when excavating short tunnels, in which they probably passed the night.

The prey of the larger wasps (Larrinæ) consists of orthopterous insects, of which more than one genus, or even subfamily, may serve as food for a single species. The prey of the smaller ones, having three perfect ocelli, seems to consist for the most part of hemipterous insects, although some use Orthoptera and a few Arachnida (spiders).

The Larridæ hunt on the wing or afoot, and may drag or even fly with their prey. The latter is frequently far larger than the wasp, and is subdued by a sting under the thorax.

The nests are almost always terrestrial, consisting in certain genera of one cell, in others of several, to many cells; they may therefore require from an hour or two to several days for their construction and provisioning. They are usually left open when the wasp is afield.

The egg of the wasp, with the exception of *Miscophus*, is placed transversely across the prosternum of the prey—a situation where it is unlikely to be injured.

The Larridæ suffer heavily from the attacks of small Tachinidæ, which follow the female to her nest and viviposit on or near the food intended for the young wasp.

Most frequently the insects nest in small, loose colonies. When nesting they are not usually timid, and can be studied from a very short distance.

The writer has found nothing in the habits of those or other Hymenoptera, however wonderful they may appear, that can be attributed to intelligence.

TABLE TO SHOW THE PREY OF THE LARRIDÆ.

Wasp.	Prey.	Order to which prey belongs.
Larra americana	Gryllidæ	Almost exclusively Orthoptera; the two exceptions(*) are Lepidoptera and Diptera.
Larra anathema (Europe)	Mole-crickets (Gryllidæ)	
Notogonia argentata	Immature Gryllus (Gryllidæ)	
Larropsis divisa	Ceutophilus sp. (Locustidæ)	
Tachytes abdominalis	Immature Tettiginæ and Acridiinæ	
Tachytes distinctus	Various Melanopli, M. femur-rubrum, usually immature; Ageneotettix deorum, mature (Acridiinæ and Tryxalinæ)	
Tachytes fulviventris	Mature Alpha crenulata (Tryxalinæ)	
Tachytes harpax	Xiphidium brevipenne (Locustidæ)	
Tachytes mandibularis	Xiphidium and immature Orchelimum,	
Tachytes mergus	Immature Tettiginæ (?)	
Tachytes obductus	Immature Tettiginæ	
Tachytes obsoletus (Europe)	Young Œdipodinæ	
Tachytes pompiliformis (Europe)	Immature Gryllus rufus, grasshoppers (Chortipus); lepidopterous larvæ *	
Tachytes rufofasciatus	Immature Melanoplus cyanipes, mature and immature Melanopli (Acridiinæ)	
Tachytes tarsina (Europe)	Immature Acridiidæ	
Tachysphex fusus	Immature Melanopli (Acridiinæ)	
Tachysphex hitei	Immature Litaneutria minor (Mantidæ)	
Tachysphex panzeri (Europe)	Acridiinæ	
Tachysphex plenoculiformis	Immature Tryxalinæ	
Tachysphex propinquus	Mature Alpha crenulata, Ageneotettix deorum and Mestobregma kiowa; immature Opeia sp. (Tryxalinæ and Œdipodinæ)	
Tachysphex quebecensis	Immature Acridiinæ	
Tachysphex semirufa	Immature Melanoplus spretus	
Tachysphex tarsatus	Immature Acridiinæ, Tryxalinæ and Œdipodinæ	
Tachysphex terminatus	Chortophaga viridifasciata immature Tryxalinæ	
Tachysphex texanus	Immature Œdipodinæ flies (Diptera)*	
Lyroda subita	Nemobius; small crickets (Gryllidæ)	
Plenoculus apicalis	Mature and immature Atomoscelis sp. (Capsidæ)	Hemiptera.— Exceptions: (†) Orthoptera and Arachnida.
Plenoculus peckhami	Immature Pamera sp. (Lygæidæ)	
Niteliopsis fossor	Immature Œdipodinæ †	
Nitelopsis inerme	Immature Capsidæ	
Miscophus spp. (Europe and U. S.)	Various small spiders, Epeiridæ †	

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Notes on Three Sesidæ (Lepidoptera) Affecting the "Missouri Gourd" (*Cucurbita foitidissima* H. B. K) in Kansas.

BY FRANCIS X. WILLIAMS.

Plates XXXI and XXXII.

Melittia gloriosa Hy. Edwards.

(Bull. Brook. Ent. Soc., III, 71; 1880.) Pl. XXXI, fig. 6.

THIS, a near relative of our common "squash-vine borer," is a very large and handsome "clearwing" moth, with brilliant red, pale yellow, and blue-black markings, strongly tufted legs, and an alar expanse in some of the large females of somewhat more than 65 mm.

As far as I am aware, *M. gloriosa* has not been reported heretofore from Kansas, where it was taken on the Kansas University Biological Survey, in two counties, viz., Seward, in the southwest, during August, 1911, and Graham, more towards the northwestern portion of the state, in August, 1912. In the latter county but one specimen was taken, while upwards of two dozen were secured in Seward county. An extensive field of sandy soil on the banks of the Cimarron river supported a number of large, wide-spreading *Cucurbita*, and it was about these ill-smelling vines that *gloriosa* was taken. The majority of the moths were in fresh condition, for many were just emerging. This seemed to take place during the morning hours, and at least as early as 8 A. M., for at 8:30 a fine ♀, but a few minutes from the pupa, was found sitting on a ripe

gourd, her still soft wings raised above her back, while beside the fruit was the extruded pupal shell. The latter were occasionally found among the vines, sometimes near the main stem, and on other occasions as far as six feet removed therefrom.

Owing to the multitude of grasshoppers, particularly of the genus *Melanoplus*, it was often difficult to approach the moth, which would be rudely disturbed or forewarned of my coming by some bungling acridian. The flight of the female moth was heavy, and accompanied by a humming sound. Whatever may be said of the protective mimicry of these insects, in that they resemble various wasps, certainly did not apply in the case observed by me, in which one of these *Melittias* was pursued, captured and greedily gobbled up by a kingbird.

Two specimens were observed laying their eggs rather indiscriminately, on both green and withered parts of the vine.

No larvæ were found, though considerable digging was resorted to. The "Missouri gourd," like the manroot (*Megarrhiza*) in California, and upon which the sesian likewise feeds, has a colossal root, penetrating the soil to no little depth.

The lepidopterist, Henry Edwards, took a specimen of this moth at San Leandro, Cal., resting "on a tree in a field of melons." It occurs likewise in Arizona, Texas, and New Mexico.

The adult moths, like most Lepidoptera whose larvæ are internal feeders, should be "degreased" by detaching the abdomen and immersing the same in benzine until the fatty matter is dissolved.

Melittia satyriniformis Hubner.

(Zutr. Exot. Schmett., F. 453; 1825.)

The "squash-vine borer" was taken in the adult state about *Cucurbita fœtidissima* vines in Pratt, Barton and Rush counties, 1911-1912. It was also collected by Dr. F. H. Snow in Clark and Douglas counties. It is considerably larger than the next species, and unlike it lacks the dark dorsal stripe of the abdomen; nor does the larva of *satyriniformis*, as far as I am aware, produce galls on the vines attacked, which is the case with the larva of *snowi*.

Melittia snowi Hy. Edwards.

(Papilio, II, 53; 1882.) Pl. XXXI, figs. 1-5; pl. XXXII, figs. 7 and 8 (galls).

Snowi expands about 23 mm. It was found to occur wherever the "Missouri gourd" was growing. This includes at least two-thirds of Kansas, beginning from its western border. The type of the species, however, was taken in eastern Kansas (Douglas county) by Doctor Snow, prior to 1883.

The following notes were made on this species secured at Hays, Ellis county, July 16-22, 1912:

In the earlier part of the season the galls or swellings on *Cucurbita fœtidissima* are comparatively small and nearly solid, and the larvæ within quite young. Both grow quite rapidly, however, and the caterpillar soon eats out most of its abode, leaving the same little more than a shell. At the above date numbers of the larvæ are deserting the galls by a ventral or nearly ventral aperture, to enter the earth. By July 19 nearly all the galls have been vacated, and a few small terminal swellings containing young larvæ remain.

Each gall contains but one larva, and is entire until the exit hole is made. As can be seen from plate XXXII, the galls are usually longer than wide; they may be of nearly uniform coloration, or else striped like the gourd. Though perhaps most frequent on the radiating and trailing stems, they may be developed from a leaf petiole, and more rarely from a tendril stem (fig. 8). They were found to vary in dimensions from about one to four inches (25-102 mm.) long, and from two-thirds to one and a quarter inches (17-32 mm.) in diameter.

Hardly has the larva abandoned the gall than small blackish flies enter it and lay their eggs therein. The numerous maggots resulting soon devour the remaining tissue, so that the gall dries up rapidly and in a measure collapses. Subsequently, small Staphylinidæ and spiders may be found within.

In but one instance was the gourd itself attacked, and in this case it appeared as though the large larva had entered it but recently.

The larva (fig. 2) when mature is about 26 mm. long, quite stout, with a small brown head, and of a dirty white color. Leaving the shelter of the gall, it burrows into the soil, there to construct a very tough cocoon, about 17 mm. long, of silk

and grains of earth. Some of these cocoons disclosed moths within a few weeks (August 16 to about 30), the pupa working its way to the surface. A goodly number, however, hibernated in their cocoons as shortened, pale yellow larvæ. Two of these cocoons, which were cut open in December, 1912, showed the inmates with the head pointing toward the narrower end of the cell. These hibernating cocoons produced imagines in 1913, from April 22 to June 14. The height of the season for this spring brood appeared to be during the first half of May, the June specimens being stragglers. This brood was reared in the laboratory, and consequently under artificial conditions.

The insect is therefore imperfectly double-brooded. No adults were taken in the field, but a reared specimen laid a number of flattened oval eggs, somewhat depressed on the disc and at the broader end. They are about .8 mm. long, of a brownish color, and under the compound microscope present a shallowly reticulate surface; in addition they are finely granulate.

It is not unlikely that *Melittia snowi,* if not already a cucurb pest, like its ally, *satyriniformis,* in some sections, will sooner or later become of economic importance.

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Vol. VIII, No. 6] JULY, 1913. [WHOLE SERIES VOL. XVIII, No. 6.

Notes on the Habits of Some Solitary Wasps that Occur in Kansas,

With the Description of a New Species.

BY F. X. WILLIAMS.

Plate XXXIII.

Family NYSSONIDÆ.

Harpactus gyponæ n. sp.

Pl. XXXIII, fig. 4, adult ♀; fig. 5, *Gypona cinerea* (its prey.)

♀. Form moderately stout. Anterior margin of clypeus broadly subtruncate, the sides rounded (when the clypeus is viewed a little from below it is broadly and shallowly emarginate), rim narrow; labrum a little bilobed mesad; inner eye margins parallel; frons (up to the anterior ocellus) a little longer than broad, and with a faint indication of an impressed median line; ocelli forming a low triangle; antennæ rather slender, somewhat thickened apically, joint 3 one-fourth longer than 4; head shining, with large scattered punctures and very fine close ones. Scutum and scutellum punctate about as in head, the suture between the two sclerites foveolate; pleuræ with fine close punctures and large scattered ones; mesopleuræ and metapleuræ with a distinct suture between them; mesopleuræ separated from the mesosternum by a carina extending from the middle coxæ to the prothoracic tubercles. Wings not extending to tip of abdomen; primaries with a rather weak stigma; the marginal cell pointed apically, the second submarginal cell receiving both recurrent nervures, the third submarginal extending a little beyond the marginal, and the submedian cell longer than the median along the externo-medial nervure; secondaries with the cubitus originating well beyond the submedian cell. Legs moderately stout and spinose, the fossorial comb (on fore legs) well developed. Disc of propodeum with the enclosed triangle bearing about fourteen carinæ, all basad except the two forming the median furrow; these two extend rather irregularly

beyond the apex of the triangle to anastomose and form the median carina in the longitudinal depression of the posterior face; along the outer sides of the triangle are a number of short carinæ; the rest of the propodeum is finely punctate and has large sparse punctures in addition. Abdomen polished, evenly rounded, strongly punctate except the first two dorsal segments, which have fine close punctures and large sparse ones; segment 2 has large coarse punctures laterally and ventrally; first ventral segment strongly carinate mesad at base and at sides; ventral segments 1 and 2 have their opposing margins somewhat raised and separate mesad; viewed laterally, ventral segment 2 is transversely excavate behind its thickened anterior margin (see cut); pygidium bare, rather

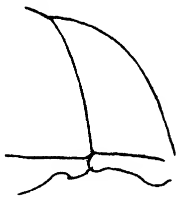

FIG. 1.

slender and narrowly rounded apically, with large coarse punctures and a distinct lateral carina for more than its apical half, the sides nearly straight. *Light rufous*, except the dark ocelli, the black tip of mandibles, sometimes the venter of the abdomen in part (which is dusky in the paratype), and a large creamy yellow lateral spot along the posterior margin of the second abdominal tergite and a weaker spot mesad on the basal half of the fifth tergite. Wings clear (with a faint infuscation in marginal and submarginal cells), yellowish in age; stigma creamy yellow, venation dark brown. Face almost bare, some silvery pile on clypeus, and plenty of it on pleuræ of thorax and propodeum and on the abdominal spots, especially the two lateral ones; elsewhere the pile is sparse. Length of type, 7.5 mm.

Two ♀♀, Grant county, Kansas; 2800 feet; July 25, 1911; F. X. Williams. Type in University of Kansas.

In Fox's key to the North American species of *Gorytes*, which genus is to some extent synonymous with *Harpactus* (Proc. Acad. Nat. Sci. Phil., 517; 1895), this insect runs either to *G. pictifrons* Fox, or *nigrifrons* Sm., depending on whether the wings are entirely clear or subapically infuscate. I do not believe it to be closely related to either of the above species, however.

Two specimens of this short-winged and rather terrestial species were observed on the flood plain of the north fork of the Cimarron river, Grant county, Kansas, at the end of July, 1911.

The soil here was sandy and interspersed with small weeds and buffalo grass; in the latter *Gypona cinerea* Uhl. (fig. 5),[1] the prey of *Harpactus* occurred. This bug, which belongs to the homopterous family Jassidæ, is an insect of stout form, and pale grayish brown color. It appeared to be partial to buffalo grass.

Harpactus does not wander far from her burrow in search of her prey. She proceeds at a rather slow and deliberate gait, inspecting the clumps of grass in a thorough manner. She very seldom ventures up a stem, and when a bug is found it is easily captured and subdued. In some cases the bugs, as if unsuitable, are not transported to the wasp's burrow, but left afield.

The first wasp of this species seen, after stinging (?) and malaxating a bug, selected a nesting site, where she dug for one hour and twenty-five minutes. After all this time and labor, however, she failed to make use of the burrow.

The second wasp was first noted at 8:54 A. M., when she was carrying a bug, holding it venter up beneath her, using her middle pair of legs for this purpose.[2] Thus burdened she disappeared into a rather large and sloping tunnel.

At 9:02 she carried in another *Gypona*, this time venter down. In this case she experienced considerable difficulty in locating her burrow, although she had found it immediately on her former trip. *Harpactus* remained within her nest for half an hour. Some of this time must have been employed in making another cell, for she finally backed out, throwing out the soil with her well-fringed fore feet, but carrying out the larger pieces of dirt in her jaws. She ran in and backed out several times, and finally came out head first (an almost invariable sign, in a number of Sphecoidea observed, that work

1. Identified by Prof. E. D. Ball.

2. It is interesting as well as instructive to note the several methods of carrying their prey employed by the solitary wasps. The Pompilidæ, or spider wasps, most frequently seize the spider by one of its legs and proceed backward with it; a smaller number of species bite off one or more of the victim's legs. The Larridæ, which store their nests with saltatorial Orthoptera, seize their victim's antennæ with their mandibles and hold the body with one or more pairs of legs; some, as certain *Tachysphex*, employ the first and second pairs of legs in dragging their prey over the ground—here the smoothest, and therefore the surface of least resistance, viz., the dorsum of the orthopteron, is next the ground. The Sphecidæ, as shall be seen, have much the same habits as the above. A species of *Diodontus* (Pemphredonidæ) seizes its small, weak victim (a plant louse) with her jaws by the ventral part of its prothorax. *Miscophus* (Larridæ), as has been observed by C. Hartman, grasps "the paralyzed spider with her mandibles by two or more of its legs, slings it on her back and marches off with it, walking forward, the spider hanging rather to one side in an uncomfortable and rather awkward looking manner." In the Nyssonidæ, *Harpactus gypona* carries the bug beneath her, holding it with the middle pair of legs, but she does not seize it in addition with her mandibles by its antennæ, which are very small and slender. It appears that this diversity in habit is in each case the best method of carrying the prey, which for various species of wasps often differ considerably in size and structure.

within is completed), made a short locality study, and sallied forth. Within half an hour she captured another bug at a distance of fourteen feet from her burrow. She had hardly gone one-third the distance to the latter when a roving tiger beetle (*Cic. punctulata*) spied her, and, giving chase, drove her off.

On digging out the tunnel, it was found to slope steeply for a short distance below the surface; the wasp within was about three inches down, seemingly employed in excavating a cell. Still further down were two neat and well-separated subspherical cells, each containing four bugs. From the ventral side of the abdomen of what I believe was the only immature homopteron of the lot, protruded what appeared to be one of the Stylopidæ; on another bug, below its lateral line and secured just outside of one of the hind coxæ, its free end pointing cephalad, was the wasp's egg.

Being unable to rear an imago from this egg, my observations on the species were here ended.

Family MIMESIDÆ.

Mimesa argentifrons Cress.

Pl. XXXIII, fig. 1, ♀; fig. 3, *Athysanus exitiosa.*

This is a slender red and black wasp about 10 mm. long, not uncommon in Kansas. One of these insects, located in Ness county early in July, had excavated her tunnel in sandy soil at the very base of a large cottonwood tree. Over the nest rose a cone formed of agglutinized grains of sand, quite frail and crude when compared with the tubes of certain *Odyneri*. The base of the cone was surrounded by loose ejected sand; the height of the whole affair above the ground was one and three-eighths inches; the width at base, two and one-fourth inches. *Argentifrons* stores her cells with *Athysanus exitiosa* Uhl,[3] a small species of Jassidæ, which she holds in the same manner as does *Harpactus gyponæ*, but the prey of the mimesid, being small in comparison with the wasp, is always borne on the wing. When obstacles were placed over the entrance to the nest, the wasp would pry them off or scratch under them, never releasing her hold on the bug, however.

The tunnel was nearly vertical, and at least eight inches deep; I was able to locate but one cell, and this contained a number of bugs.

3. Identified by Prof. E. D. Ball.

Family SPHECIDÆ.

Palmodes rufiventris Cress. and *læviventris* Cress.

These are both active wasps about 20 mm. long. Both have dark, smoky wings; *rufiventris* has the abdomen reddish, while *læviventris* is all shining black. Both of these wasps were noted in western Kansas, where they preyed upon *Stipator*, probably *stevensonii*, one of the Orthoptera of the subfamily Decticinæ, or shield-back grasshoppers.

Priononyx thomæ Fab.

This is a quite common and rather slender wasp with subhyaline wings, red abdomen, head and thorax more or less ornamented with silvery pile, and with a length of about 15 mm. The insect has much the same habits as *P. atrata*, a larger and entirely black species. Like the latter, *thomæ* has the habit of depositing her prey in a place of safety while she excavates her one-celled tunnel. Of the two specimens observed nesting, both secured a tryxaline locust for their burrow, one belonging to the genus *Amphitornus*, the other to *Aulocara*.

These wasps, at least in the male sex, in common with many other Specidæ, congregate in some numbers on weeds, where they pass the night or remain during unfavorable weather. Such "clumps" of wasps are a common sight on Russian thistle in western Kansas.

Priononyx atrata St. Farg.

Pl. XXXIII, fig. 2, vertical section of burrow containing an *Aulocara* locust; fig. 6, dorsal view of *Melanoplus lakinus*, showing wasp egg (*E*) *in situ*; fig. 7, ♀.

A number of these very interesting shining black wasps were studied afield. Their highly specialized habits are scarcely if at all inferior to those of the well-known *Ammophilas*.

P. atrata occurs plentifully throughout western Kansas, but it was in the southwestern portion of the state that this species was best observed.

It preys upon several species of the short-horned grasshoppers or locusts (Acridiidæ), insects always far weightier than the wasp in question. Only one locust is stored in the short, steep burrow. But the prey is captured before the nest is begun (the contrary is true in all the Larridæ I have observed), and usually placed on some slight elevation,[4] as a tuft of grass, while *atrata* excavates her burrow.

4. The Peckams have noted a similar habit in some of the Pompilidæ.

The nesting activities were in a few cases watched from beginning to end, and the following field notes will serve to illustrate in a degree the habits of the female wasp:

Grant county, July 21, 1911. While walking in the sandy valley of the north fork of the Cimarron river, I came across a *Priononyx atrata*, at 2:35 P. M., astride a locust (*Aulocara elliotti*), which lay venter down on the ground. The wasp held the base of the locust's antennæ in her jaws and was dragging it to a tuft of grass near by. She placed it on this slight elevation, and after a short search selected a hoof print hard by in the sand as her nesting site. Bracing herself well with her second and third pair of legs, she dug very rapidly under the broken crust of sand with her jaws and fore legs. At intervals she ceased from her labors to examine the locust on the tuft of grass, two feet away. This being a region infested with ants, the precaution was well taken. She was apparently worried at being able to locate her prey only after quite a search, and so when she finally found the same she seized it, and, bringing it much nearer her incomplete burrow, again placed it free from the ground, on a bent grass stem. In a short time the burrow was finished and the locust stored within, but not before a tachinid fly had viviposited upon the latter.

Priononyx filled up the tunnel by backing in, throwing in the soil at the same time, subsequently using her head, more specifically, her clypeus and jaws as a packer or ram. While thus engaged she sometimes assumed an almost vertical position. She dug a little in the opposite side of the hoof print in order to supply more soil to fill in with; when this was accomplished she did considerable leveling, smoothing over the tunnel site with brisk strokes or her feet. This done to her satisfaction, she sought to further disguise the place by depositing thereon pieces of soil (often several times her own weight), twigs, etc. She did this last work very carefully. At about 4:10 P. M. the task was complete. After taking a short rest she sallied forth afoot in search of her prey. Her right of way was unquestioned; indeed, the various locusts in her path leaped away at her approach, and on two occasions an affrighted *Hadrotettix* (a large œdipode locust) spread out its wings in a startling fashion, while still other acridians raised their hind legs in a defensive attitude. Finally, at 4:20 P. M., she found her prey—a mature *Aulocara*. Pouncing upon it,

she clasped the under side of its thorax, her head toward the caudal end of her leaping prey, her jaws applied to the latter's body. She clung on tenaciously and soon quieted it with a sting, administered somewhere on the locust's neck. After this brief but strenuous period she took a short rest; then pulling her prey up a Russian thistle plant until the former was about one and one-half inches above the ground, she set to work locating a nesting site. This she soon found, only six inches away. She commenced to dig at 4:26 P. M. She visited her prey on the Russian thistle three times before the hole was excavated, which was at 5 P. M. Finally grabbing the *Aulocara* by the antennæ, she dragged it to just before her burrow, into which she backed. A little *Tachina* fly which had been carefully watching the wasp while digging her tunnel, and even following her on her occasional tours of inspection to the weed where the *Aulocara* lay, now availed herself of the opportunity presented her by the wasp's disappearance in the tunnel to viviposit at the base of the locust's elytron. Hardly was the parasite's work accomplished when *Priononyx*, emerging, seized her victim by the antennæ and dragged it within. She remained inside long enough to lay her egg on the locust. She filled her burrow as in the first instance, and completed her work at 5:25 P. M., or one hour and fifteen minutes after she had filled up her first nest. Like the first tunnel, this one was in a depression where the soil crust had been broken. The wasp was caught and her nest dug up. This sloped quite steeply up to the subhorizontal cell; here, on its venter, lay the locust, the rather long, curved wasp egg (*E*, fig. 6) secured in the membrane just anterior to one of the hind femora and immediately dorsad the hind coxa. This position is always chosen by this wasp. The hole was of rather large bore and measured two inches deep by two and one-half inches long.

These wasps sometimes occur in small, ill-defined colonies, and while at work at their tunnels could often be located by reason of the squeaky buzz which they emitted from time to time, and which was plainly audible from a distance of a dozen feet. In Morton county, where the soil was rather wet and heavy from recent heavy rains, the wasp used her jaws to a large extent and brought out considerable loads of earth, which she held between her open jaws and her fore legs. She carried out as many as four or five loads per minute. The tunnels are

quite uniform in structure, but may not be more than one and one-half inches deep and less than two inches long.

The orthopterous prey of *Prionony.x atrata* is rather varied. As far as observed, the victims were always mature and usually of the smaller species of *Melanoplus* (including *lakinus*). A large specimen of *atrata* was observed by one of the members of the Entomological Survey of 1911, with a ♀ *Melanoplus differentialis,* an insect of considerable strength and magnitude. The author took an *atrata* in Seward county which had captured a ♀ *Mermiria neomexicana.*

While the evidence at hand is incomplete, it seems more than probable that the common red-banded bembecid wasp, *Stizus unicinctus* Say, plays the part of a burglar and uses the locust captured by *Prionony.x atrata* as food for her own young. *Unicinctus* is a rather compact insect, somewhat inferior in size to and less powerful than the sphecid. It occurred plentifully in western Kansas, where it was sometimes seen flying low over the ground, alighting now and then as if inspecting the locality for a nest of some sort. In Stanton county one of these wasps was observed to hover about a freshly made tunnel, apparently that of a *Prionony.x,* which it entered while the sphecid was away. The latter had brought an *Aulocara* near this burrow, which, being occupied by *Stizus,* was finally deserted by the disgusted *Prionony.x.*

In Morton county, July 7, 1911, I came upon *Stizus unicinctus* engaged in smoothing over a spot with her feet. I unearthed what proved to be a filled-up burrow, which in form and dimensions resembled that of a *Prionony.x.* In the single cell lay a *Melanoplus.* But where the *Prionony.x* egg was to be expected on this locust was only a small bit of soft matter, probably the remnant of the specid egg destroyed by the *Stizus,* while cephalad of these remains was a short wasp egg, doubtless that of *Stizus.*

Certainly the short-legged *Stizus unicinctus* does not appear to be a sufficiently powerful insect to capture and subdue locusts of the size and vigor as those which serve as the prey of *Prionony.x.*

Further observation upon the interrelation of these two insects is needed, so that their complete life history may be brought to light. Although much has been written on the solitary bees and wasps, the data on their postembryonic development is exceedingly meager, and no doubt offers a wide and interesting field for the investigator.

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CONTENTS.

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The Biology of Some Kansas Eumenidæ.

BY DWIGHT ISELY.

(Submitted in partial fulfillment of the requirements for the degree of master of arts.)

Plates XXXIV to XXXVII.

INTRODUCTION.

THIS paper is based on field observations and collections made by the author while connected with the Biological Survey of the University of Kansas, in northwestern Kansas during the summer of 1912. Specimens of fully developed insects, upon which biological notes were based, were identified by means of the Snow Entomological Collections. The caterpillars, parasitic larvæ, and cocoons, were identified to species or family, as the case might be, by Francis X. Williams, assistant curator of the Snow Entomological Collections.

The drawings of nests were made by the author, first in the field, and then were copied in the laboratory. They were inked by Miss Orrel M. Andrews, a graduate student in entomology. Four drawings of wasps, made from specimens in the collection, are entirely her work.

The author takes this opportunity to thank Prof. S. J. Hunter, head of the department of entomology, to whom he is indebted for general oversight of the work and much helpful criticism. He also wishes to thank Mr. Francis X. Williams for help in studying the Eumenidæ both in the field and in the laboratory; Mr. H. B. Hungerford, instructor in entomology, and Miss Ruby C. Hosford, a graduate student in the department, for reading and criticizing the manuscript; and Miss Orrel M. Andrews for assistance in illustration.

PURPOSE OF THESIS.

An account of the biology of almost any wasp must be, for the most part, an account of nesting activities. Nest building and provisioning is the mother wasp's life work. Her interrelations with other insects, the food habits of her offspring, and consequently, to a large extent, her economic importance, are directly connected with her nest and its contents. A study of the larva, its habits and modifications in structure, refers back to the nest. Those activities which in no way relate to the nest—the mother wasp's search for food for herself, her avoidance of perils daily, and the idle male's pastimes—those activities are but incidents in the story. The main plot centers about the nest.

The study of wasps, bees and ants owes much of its fascination to their nesting habits. The features in the accounts of their lives are more than growth and development. A range of talents—useless to ordinary insects—are demanded of them in the building and provisioning of their nests. Their ecology becomes more complex. The nest builders' lives are made purposeful; their chief aim becomes more than to eat and avoid being eaten. By this labor for their progeny a fascinating and highly developed display of instincts is called forth.

The Eumenidæ have received my special attention both because of their attractive habits and because of their convenience for study. The varied architectural skill of the eumenids makes them attractive, for within the group are potters, miners, masons, carpenters, and more or less degenerate builders. As solitary insects they offer advantages, in that the activities of the individual insect can easily be isolated and studied. This solitary habit also removes the opportunities for imitation, and thus makes instincts more clearly defined. In western Kansas the Eumenidæ is an important group, being well represented both in species and numbers.

A study of the nesting habits of Kansas Eumenidæ, then, is the chief burden of this paper. Nine species are to be discussed. So much is it a study of nesting habits, that no wasps whose nesting habits have not been observed are considered. However, with the account of nesting habits are notes on all the other activities of these nine wasps that I observed, and some notes on immature stages. In addition to the biological notes, I have included descriptions of the species discussed. I

have also added brief summaries of some of the literature available on the biology of the Eumenidæ.

In my study my purpose was only to study and record accurately the activities of these wasps. While the study of instinct is fascinating, it has not been my aim to accumulate evidence that would have a bearing on the theories of insect instinct and intelligence. Some data, however, relating to these theories have been collected, but their collection has been incidental and often accidental—it was a by-product of the work.

SYSTEMATIC POSITION AND DISTRIBUTION.

The family Eumenidæ is placed by systematists with the social Vespidæ and the parasitic Masaridæ in the superfamily Vespoidea. Members of this superfamily can readily be distinguished from the fossorial wasps by the anterior wings, which are folded in plaits when at rest. Because of the club-shaped antennæ, the family Masaridæ is set apart from the other two families, which have more or less filiform antennæ. A single spur on the middle tibia, instead of two spurs, and unidentate tarsal claws, are the chief morphological differences between the Eumenidæ and the Vespidæ. These differences are not considered by all to be of sufficient importance to be used in the division of families. Sharp says: "We anticipate that the Eumenidæ and the Vespidæ will ultimately be found to constitute one family." De Saussure did not consider the morphological differences of sufficient importance to make even two distinct tribes of the solitary wasps and the social wasps; he divided them because of the difference in habits.

In habits there is little likelihood of confusing these allied families. The social wasps, like the social bees, have three castes—queens, drones, and workers. The brood cells in the nests of the community are built in combs. The solitary wasps have only two forms, and all the work is done by fully developed females. There is no division of labor, for each wasp builds its own nest. Both groups are predacious, but, according to De Saussure, the solitary wasps are the more so.

The Eumenidæ, according to Sharp, are distributed widely over the world in temperate and tropical regions. Representatives of the genus *Odynerus* are found even on the isolated Hawaiian Islands. About eight hundred species have been described.

REVIEW OF LITERATURE.

The habits of the Eumenidæ vary widely. Even after my summer's study on the Biological Survey, I had no conception of the extent of variation, for previous to that summer I had made no study of the group either by reading or otherwise. After returning, a review of the available literature on the subject greatly widened my view and cast light on many details that I had entirely overlooked. Therefore, before beginning an account of my limited observations of a single summer I shall briefly summarize the work of others from various parts of the world, paying special attention to American observers.

De Saussure[1] says that the members of the genus *Zethus* by their habits seem to establish a "lien" between the Odynerinæ and the social wasps. He writes: "Certain species (of *Zethus*) manifest a tendency toward social habits. They form small agglomerations of nests, which resemble a little the irregular nests of bumblebees, but grouped yet more confusedly. But there always prevails this difference between cells formed by the social and those made by the solitary Hymenoptera, that the first have a cylindrical inner space, while the second are rather extended masses which are not in regular juxtaposition, so that they seem to be more like spheres and ellipsoids joined together than cells constructed side by side on a general plan. In other words, the solitary never seek to form a comb, although they sometimes form an agglomeration of cells."

In the genera *Zethus* and *Eumenes,* according to Ashmead,[2] are potters. They build globular cells of clay and mud, which are attached by a pedicel to a twig. The cell of *E. fraternus* is usually attached beneath the large leaves of the scrub palmetto. According to Doctor Harris, it feeds upon cankerworms in Massachusetts. In Florida it feeds on other small caterpillars. From these cells, in Florida, were bred *Phippiphorus dimidiatus.*

An instructive summary of the habits of a number of eumenids is given by Sharp.[3] His account of nesting habits of *Eumenes* is as follows.

1. Syn. Am. Wasp Sol., pp. 13-14.

2. Psyche, May, 1894, pp. 76-78

3. Sharp; Cambridge Nat. Hist.. vol VI pp. 7? 78.

Fabre has sketched the habits of a species of *Eumenes*, probably *E. pomiformis*. This *Eumenes* constructs with clay a small vase-like earthenware vessel, in the walls of which small stones are embedded. This it fills with food for the young. The food consists of caterpillars to the number of fourteen or sixteen for each nest. These caterpillars are believed to be stung by the parent wasp (as in the case of the fossorial Hymenoptera), but complete evidence of this does not seem to be extant, and if it be so, the stinging does not completely deprive the caterpillars of the capacity of movement, for they possess the power of using their mandibles and of making strokes or kicking with the posterior part of the body. It is clear that if the delicate egg of *Eumenes* or the delicate larva that issues from it were placed in the midst of a mass of this kind it would probably suffer destruction; therefore, to prevent this, the egg is not placed among the caterpillars, but is suspended from the dome covering the nest by a delicate thread, rivaling in fineness the web of the spider, and, being above the mass of food, it is safe. When the young larva leaves the egg it still makes use of the shell as its habitation, and eats its first meals from the vantage point of suspension. Although the mass of the food grows less by consumption, the little larva is enabled to reach it by the fact that the egg shell splits up into a sort of a ribbon, and thus adds to the length of the suspensory thread, of which it is the terminal portion. Finally the heap of caterpillars shrinks so much that it can not be reached by the larva even with the aid of the augmented length of the suspensory thread; by this time, however, the little creature has so much increased in size and strength that it is able to take its place amongst the food without danger of being crushed by the mass, and it afterwards completes its metamorphosis in the usual manner.

E. unguiculata, according to Perris,[3] constructs an earthen nest of irregular shape, containing three cells in one mass. *E. coarctata*,[3] a British species, attaches its nest to a twig of a shrub, while both previously mentioned species of this genus build their nests upon a flattened surface. *E. conica*, according to Horne,[3] constructs, in Hindustan, clay nests with very delicate walls. It is much attacked by parasites.

The likeness of the earthen nests of *Eumenes* to pottery has been spoken of by many authors. Howard[4] writes: "Prof. O. T. Mason says that certain beautifully shaped Indian vessels and baskets have precisely the same form as these cells, and he thinks that the observant aborigines may have deliberately copied the insect design."

4. Insect Book, p. 31.

Sharp's account of the habits of *O. reniformis*, drawn from Fabre, is as follows:

This insect (*O. reniformis*) provisions its cell with small caterpillars to the number of twenty or upwards. The egg is deposited before the nest is stocked with food; it is suspended in such a manner that the suspensory thread allows the egg to reach well down towards the bottom of the cell. The caterpillars placed as food in the nest are all curled up, each forming a ring approximately adapted to the caliber of the cell. Fabre believes these caterpillars to be partly stupefied by stinging, but the act has not been observed either by himself, Reaumur, or Dufour. The first caterpillar is eaten by the wasp larva from its point of suspension. After this meal has been made the larva is supposed to undergo a change of skin; it then abandons the assistance of the suspensory thread, taking up a position in the vacant chamber at the end of the cell and drawing the caterpillars to itself one by one. This arrangement permits the caterpillars to be consumed in the order in which they were placed in the cell, so that the one that is the weakest on account of its longer period of starvation is first devoured. Fabre thinks that all the above points are essential to the successful development of this wasp larva, the suspension protecting the egg and the young larva from destruction by pressure or movement of the caterpillars, while the position of the larva when it leaves the thread and takes its place on the floor of the cell ensures its consuming food in the order of introduction.

The species of *Odynerus*[2] are very subject to the attacks of parasites. They are destroyed to an enormous extent by Chrysididæ and by a fly, *Argyromœba sinuata*. Mr. R. C. L. Perkins observed *O. callosus* forming their nests in a clay bank and provisioning them with larvæ, nearly all of which were parasitized.

Perkins[3] has also observed some of the species of Hawaiian *Odynerus* make a single mud cell very like the pot of an *Eumenes*, but cylindrical instead of spherical. This little vessel is often placed in a curled-up leaf, which also shelters both spiders and young mollusks of the genus *Achatinella*. *O. punctum*, an East Indian species, according to Horne, nests in holes in door posts.

Many of the genus *Odynerus*, according to Ashmead,[2] appropriate galleries and cells made by different bees, and old mud daubers' nests. *O. errings*, in Florida, was observed making its nest in a door lock and in holes in a board fence. He also reared it in cells constructed in old oak galls of *Amphibolips cinerea*. Nine specimens of varying size were reared from a single gall. *O. allophaleralus* has been bred

from a gall of *A. confluens*. *O. fulvipes* was observed by Walsh building in a spool. *O. capra* was observed by Rev. T. W. Fyles provisioning its nest with the larch sawfly (*Nematus erichsonii*).

Odynerus is parasitized by Chrysididæ and by two or three ichneumonids. *Linoceras junceusi* is the only ichneumonid reared from them in this country. Walsh records having bred *Chrysis cœrulans* var. *bella* from *E. fraternus*. Cocoons of *Meteorus* and *Microgaster* have been found in cells of *Odynerus*. These may have been parasitic on caterpillars stored.

A. Davidson[5] gathered twigs of *Nama parryi* on Mount Wilson, California, which contained cocoons of *O. rufobasilaris*. The cocoons resembled finely grained caddis-fly cases. The outer surfaces were covered with sand; one end of the cocoon was truncate and the other rounded. The wasp, presumably, after provisioning each cell, adds a quantity of sand, which is afterward utilized by the larva. From ten cells four parasites (*Epistenia odyneri*, a chalcid) emerged.

O. reniformis is described by Dufour[6] as a wasp which burrows in a firm sand bank or in a clay terrace. An egg is laid at the bottom of each burrow, over which is placed green caterpillars, rolled together, yet living. Over the entrance of the burrow is an arcuate earthen tube. Dufour also described the habits of *O. lævipes*, which makes its nest in a dry bramble twig. This wasp also deposits its egg at the bottom of the cell and stores lively caterpillars above it.

Some of the genus *Odynerus*, according to Froggatt, build clay nests in various shapes, sometimes forming a finger-shaped row of clay cells, or rounded, cup-shaped chambers.

Observations on the nesting habits of five species of *Odynerus* are recorded by the Peckhams.[7] Three of these wasps nested in plant stems, one excavated a burrow in the ground, and the fifth made her nest in the mouthpiece of a horn.

O. perennis nests in July in raspberry and blackberry stems and partitions the cell with mud. In one cell were sixteen caterpillars, nearly one-third of which were dead.

A one-celled nest of *O. conformis* and a two-celled nest of *O. anormis* were found in stalks. Both nests were freshly provisioned, and in all three the egg was hung from the side

5. Psyche, vol. VII, p. 335.

6. Ann. Sci. Nat., ser. 2, vol. 11; 1838. Transl. by Verhœff, Ent. Nach., XIX, p. 49.

7. Wasps, Solitary and Social, pp. 89-95.

about one-third way down. In the nest of *conformis,* from which all but one of the caterpillars had fallen out of the cell, the egg hung loosely against the wall. "In the other nests," the account reads, "the lower part was packed tightly with sixteen small larvæ, upon which lay the egg, supported in a horizontal position, although attached to the side wall exactly as *conformis,* and above were eight more caterpillars, the whole forming a compact mass shut in by the usual partition of mud. So closely were they crammed in, that after counting them we were unable to get them all back again, and although motionless in their narrow quarters they became quite active when relieved from pressure. This is an entirely different arrangement from that of *O. reniformis* (described by Fabre), and since the larva is in contact with the caterpillars from the moment of hatching, the manner of the egg-laying has no significance in relation to the safety of the young.

Conformis, upon hatching, sloughed off the skin but remained attached to it, thus doubling the length of the thread by which it hung. The larvæ of *anormis,* upon hatching, broke from their attachment. They cocooned on the fifth day after hatching.

O. vagus was noted bringing pellets from a "sharp-edged" hole in the ground, dropping these ten or twelve inches from the burrow. This wasp was much disturbed by a red-headed match stuck in the ground two inches away from her burrow. For half an hour she refused to work until the offending object was removed.

A three-celled nest of *O. capra* was found in the mouthpiece of a tin horn. The cells contained a larva and a supply of very lively caterpillars, of which ten were in the cell most lately formed. One egg was found in another cell before it was provisioned. In four days the larva made its appearance, sloughing off the skin, and being free to crawl away.

Habits of two eumenids, *O. dorsalis* and *O. arvensis,* which I have studied, have been described by Mr. Carl Hartman in a bulletin published by the University of Texas, entitled "Observations on the Habits of Some Solitary Wasps of Texas."[8] These observations were made near Austin, Tex., during the summer of 1903.

Mr. Hartman writes: "*O. dorsalis* builds pretty mud cells on the ground, choosing a place hidden from view by a clump of

8. Bul. Univ. Tex., No. 65, pp. 6-10.

grass. The cells are broadly spindle shaped, pointed at one end, which is left open until the cell is stored. The chambers do not touch each other for more of their length than is necessary for their mutual agglutination. This almost entire independence of the cells entails a considerable waste of building material as compared with the habit of *Pelopæus cenentarius*, which builds its cells side by side in rows and tiers of rows."

A day's work with *O. dorsalis* is to provision one cell and construct another. The newly constructed cell is used as a resting place for the wasp herself during the first night.

In order to take a picture of the nest, Mr. Hartman pulled away some grass blades and set up his camera. This disturbed the wasp very little. "After once flying away for a minute," he writes, "and circling about once or twice, she settled and placed the caterpillar in the nest. . . . This done, she cleaned her antennæ and flew away without seeming to take her bearings."

Very small caterpillars—cotton worms—were stored. Of seven found in one cell four responded perceptibly to stimulation. The author believes that *Odynerus* occasionally takes a caterpillar for her own delectation. He also observed this wasp picking up unwary ants that passed too near her as she was lying in her cell one morning before going to work.

From six cells four wasps emerged in thirty-nine days each. The length of the stage for the egg and larva together was twenty days. The other two wasp larvæ were killed by mites.

I shall quote nearly the whole of Mr. Hartman's notes on *O. arvensis*. He writes:

This species of *Odynerus* does not possess the architectural skill of its cousin just described. Its home is not such an elaborate domicile, built, as it were, for show as well as for use, but consists of any convenient crevice in a wall or fence post. The nest is completed by closing the opening of the crevice with mud, much after the fashion of *Trypoxylon*. I have made a few observations on two nests of this *Odynerus*; those on the conditions of the caterpillars found are of particular interest. In general the following facts do not justify Fabre's conclusion, which he based on the habits of *O. reniformis*.

At noon August 4 a female *arvensis* was closing her nest in the niche of a brick wall. A few days before a *Trypoxylon* had emerged from the very niche now intended to be the cradle of another wasplet. I immediately opened the nest and drew out eight caterpillars, all of which were alive—six of them, in fact—so lively that they wriggled around in the small vial to which I had transferred them. I found no egg at first, but looking carefully into the dark recess, I discovered the egg suspended

from the ceiling of the little room. After breaking the suspensory thread with a knife and brushing the egg out, I placed it among the caterpillars in the bottom of the vial. Very few wasp's eggs could stand the rough handling which this egg received. The explanation of its endurance lies in the toughness of its shell. The larva hatched in two and one-half days, having shed a tough translucent shell which could safely be handled with a forceps. After fifteen hours the larva had attached itself to a writhing caterpillar and had grown perceptibly. . . .

The length of the egg stage of *O. arvensis* is about two and a half days; of the larval stage, four and a half days; of the pupal stage, eighteen days.

Another nest which I observed an *arvensis* store and close on August 14 I opened nearly a month later (September 9). I was expecting to see a wasp emerge by this time, and had placed a bottle over the entrance to receive it. I found in the nest no offspring of the wasp, but a red pupa of a fly and fourteen caterpillars, of which four had dried up, three were dead though in good condition, and seven were actually alive.

Three caterpillars lived forty-three days, one forty-six days, and one remained for fifty-eight days in a condition good enough to be added to any waspling's bill of fare.

A survey of these few facts would seem to indicate that while the suspension of the egg and the young larvæ is a desirable condition and increases their chances of successful development, yet it is not an essential condition, as Fabre contended. Nor is it essential, in consideration of the longevity of the paralyzed prey, that the caterpillars be devoured in the order in which they were stored.

Three Kansas Eumenidæ—*O. annulatus*, *O. geminus*, and *O. foraminatus*—were observed by Messrs. Hungerford and F. X. Williams[9] in northwestern Kansas, while on the Kansas University Biological Survey during the summer of 1910. *O. annulatus* is one of the species whose nesting habits I observed. I collected a number of specimens of *O. geminus*, but did not observe any of its nesting activities.

The excavation of two nests of *O. annulatus* was observed by the authors. These nests were burrows dug in open spaces in the prairie; over the burrow was constructed a short, almost vertical tube. The wasp moistened the earth, before digging, with water from a lagoon; in digging she employed her mouth parts and fore legs. Excavated earth was used in tube construction, and the rest carried off and dropped several feet away. "It is noteworthy," they write, "that *Odynerus* in disposing of the pellets of earth (which she does on the wing) does not cast them about indiscriminately, for it was observed that one wasp dropped them at a distance of from four to six

9. Ent. News, vol. 23, pp. 250-255.

feet from the nest, while the other disposed of hers at a distance of about three feet northwest of the burrow."

The nests were opened three days later. Both nests were one-celled. One tube was nine-sixteenths inch high; the other was one and one-thirtieth inches high. Its diameter was nearly one-fourth inch, inside measurement. In one case the tunnel was vertical for one and one-fourth inches, and from that depth curved in a westerly direction. The terminal cell was slightly greater in diameter than the gallery, and was horizontal. One cell contained an egg and two caterpillars; evidently provisioning had just begun. In the other cell were nine caterpillars and a small grub. The cell was closed with "a wad of packed soil one-fifth inch thick."

O. geminus is a burrowing wasp, but does not cover the entrance with a tube. A part, if not all, of the pellets are dropped within two or three inches of the hole. "The tunnels of *geminus*, which were often rather closely associated, were in barren soil or more or less sandy loam, with plenty of lagoons in the vicinity." These burrows included a number of cells, some as many as eight. The authors suggested that possibly *geminus* utilizes its holes for a second brood, for none of those examined would indicate that they were newly made. One nest contained refuse of old cocoons, one presumably of a parasite, another revealed three pupal cells of a muscoidean fly. The lepidopterous larvæ stored was probably *Pholisora catullus*.

In comparing the nest of the two species, *O. annulatus* and *O. geminus*, the authors suggest that the tube of the former protects the nest from attacks of insect parasites.

Several specimens of *O. foraminatus* were dug out of a decayed stump, which also sheltered a nest of *Crabro interruptus*. The brood was apparently just emerging. The cells of *foraminatus* were separated by mud partitions.

Monobia quadridens[10] nests in an old burrow of a carpenter bee (*Mylocopa virginica*). The sides of the burrow are renovated by a thin veneering of clay; then the burrow is filled with clay cells from the bottom upward. More than one wasp had been seen coming and going out of a single burrow. It preys on large cutworms. According to Comstock,[11] this species bores in solid wood.

10. Psyche, May, 1894, pp. 76-78.

11. A Manual for the Study of Insects, p. 660.

The Australian genus *Abispa*[12] constructs a nest with a funnel-shaped entrance and of so large a size that it might pass for the nest of a colony instead of a solitary wasp.

The females of *Rhynchium oculatum*,[12] according to Lichtenstein, construct from fifteen to twenty cells in pithy plants, and destroy from 150 to 200 caterpillars each. The East Indian *R. carnatium* uses hollow stems of bamboo. *R. nitidulum* constructs clay cells similar to those of *Eumenes,* and fixes them firmly to wood.

A number of observers have recorded food habits of various Eumenidæ. Riley[13] writes that the fraternal potter wasp, *Eumenes fraternus*, according to Harris, stores its cell with cankerworms. Its clay nests are always closely packed with eighteen to twenty worms. These nests are attached to goldenrod or other plants in the open, or they are cemented under loose bark of some trees. Sometimes they are even attached to leaves of deciduous trees.

E. B. Southwick[14] also writes regarding *Eumenes fraternus,* which is one of the worst enemies of the parsnip worm (*Depressaria heracliana*). He says: "One of these wasps would alight on the umbel in which a web was situated, and would begin to peer into it first at one end and then at another, all the time getting more and more excited. On discovering the worm within, it would commence to run its abdomen into the end of the web with its head toward the opposite end, as if trying to eject the occupant, and every now and then darting at the orifice as the worm would approach it. In this way it would work for a long time, first at one end and then at the other, no doubt each time thrusting out its sting." In this way the cell was packed at each end until it became too short to cover the larva. When it showed itself it was grabbed by the mandibles of the wasp and dragged forth with more or less difficulty. By repeated jerks and stings the larva was dislodged, then stung again and carried away by the wasp.

Nests were found on an old goldenrod stalk in an open wood. Four cells were all filled with larvæ, many of which were larvæ of the parsnip webworm.

M. J. Lichtenstein[15] writes of *O. crassicormis*. This wasp,

12. Cambridge, Nat. Hist., vol. VI, pp. 72-78.

13. Rep. U. S. Ent. Comm., III, p. 177.

14. Ins. Life, vol. V, p. 107.

15. Bull. Ent. Soc. Fr., vol. IV, p. 86.

he says, stores its nest with coleopterous larvæ of the genus *Phytonomus* (one of the Curculionidæ), either *P. variabilis* or *P. ruspiciosur,* which are common on Lucerne.

Marlatt[16] described the food habits of a small *Odynerus.* A small *Odynerus* was observed to examine the leaves of the black locust (*Robinia pseudacacia*). Some of these leaves were sewed together by the larva of *Pompelia gleditschiella.* The wasp eventually rested on the upper surface of one of these tied-together leaves; then ran to the under side and vigorously bit through the lower leaf. The hole was cut through in a few seconds. Then it grasped *Pompelia,* gave it a few turns with its mandibles, and flew away. Examination showed that the tree had been thoroughly worked over by *Odyneri.*

Schwarz[17] said that the cells of *Odynerus* which are in old burrows of *Anthrophora* around Washington are always stored with tortricid larvæ.

The Hawaiian species, according to Perkins,[18] prey on larvæ of the Pyralidæ, Noctuidæ, and Microlepidoptera.

Descriptions of Species.

There are nine species of the Eumenidæ upon whose nesting habits I have made observations. There are *Eumenes bolli, fraternus; Odynerus arvensis, annulatus, dorsalis, hildagi, papagorum, sulphuritinctus;* and *Pterochilus 5-faciatus.* I shall now give a table to distinguish these species, and detailed descriptions of them.

There is little claim for originality for these descriptions. For the most part I have compiled them from those prepared by De Saussure, Cresson, and Viereck. In some places I have quoted these authors directly, while in others I have paraphrased their descriptions, making some additions and subtractions.

The changes which I have made are mostly of minor importance. My chief aim in revising these descriptions at all is to give them more uniformity in regard to arrangement, terminology, and parts described, which would scarcely be possible in unaltered work of three different authors. Also, I wish the descriptions to conform to the Kansas varieties, and am endeavoring to make the former descriptions as brief as possible, for this paper is primarily biologic, not taxonomic.

16. Proc. Ent. Soc. Wash., vol. IV, pp. 172-173.

17. Proc. Ent. Soc. Wash., vol. IV, p. 173.

18. Fauna Hawaiiensis, vol. 1, pt. 1, p. 31.

The genera represented by the species discussed can be separated by the following table:

Anterior wing plicate in repose; middle tibiæ with a single terminal spur; tarsal claws unidentate .... EUMENIDÆ
- A. Abdomen petiolate; labial palpi normal, four-articulate .... *Eumenes*
- AA. Abdomen sessile or subsessile.
  - B. Labial palpi three-articulate, bipectinate, fringed with long hairs. *Pterochilus*
  - BB. Labial palpi four-articulate, normal .... *Odynerus*

The following should separate the two species of *Eumenes:*

- A. Wasp, largely black .... *fraternus*
- Wasp, largely yellow ferruginous .... *bolli*

The following table should separate the species of *Odynerus:*

- A. First abdominal segment punctate dorsally.
  - B. Small wasps, 8 mm. long; a free yellow lateral spot on second abdominal segment .... *papagorum*
  - BB. Medium-sized wasps, 13 mm. long; no free yellow lateral spot on second abdominal segment .... *sulphuritinctus*
- AA. First abdominal segment not punctate dorsally.
  - B. Margin of second abdominal segment reflexed dorsally .... *hildagi*
  - BB. Margin of second abdominal segment not reflexed dorsally.
    - C. Large species, 17 mm. long; clypeus finely punctate .... *dorsalis*
    - CC. Medium-sized species, 12 to 15 mm. long.
      - D. Largely black wasp; clypeus strigate punctate.. *arvensis*
      - DD. Largely ferruginous wasp; clypeus simply punctate. *annulatus*

O. arvensis Sauss.

O. arvensis Sauss.; Rev. de Zoöl. XX; 1869.
O. arvensis Sauss.; Syn. Am. Wasps Sol., pp. 270-272; 1870.

♀. Total length, 14 mm.; wing, 11 mm.
♂. Total length, 12 mm.; wing, 9 mm.

♀. A medium-sized, mostly black, coarsely punctured wasp. Clypeus widely pyriform strigate punctate; truncate at tip, one-toothed at sides of truncated margins. Thorax slightly widened in front; scutellum with low, indistinct medium carina; postscutellum transversely crenulate, the laterosuperior ridges blunted or effaced; the lateral edges of the hinder plate produced into a dentiform angle. The first abdominal segment smooth, truncate and a little rounded at the base; the second segment short, densely punctured, its posterior border offering a wide depressed zone, widened in the middle, very coarsely cribrose; the following segments similarly punctured. Insect black. Mandibles red; a spot at their base and a broad basal band in the clypeus yellow; inner border of orbits, a spot behind each eye and a spot on the front either yellow or reddish; scape of the antennæ red, with a black line above. Anterior border of the notum yellow, often followed with red; tegulæ yellow or red; postscutel and a spot on each side of the metathorax above, yellow; segments of the abdomen apically bordered with yellow, the first having its border on each side widened or confounded with a spot or oblique band, which is yellow surrounded with red, leaving above a black, square spot. Legs yellow, black at the base. Wings smoky or a little reddened, with a light violet reflection.

♂. Smaller. Clypeus polygonal, yellow, wider than long, truncate on its anterior border, offering a very small tooth on each extremity; its anterior portion a little prolonged, so that the polygon is not regular; hook of the antennæ black or ferruginous; mandibles and ornaments of the head yellow or orange; a red dot on the flanks before the tegulæ; often the posterior border of the prothorax red. Fifth abdominal segment often bordered with yellow.

Habitat: "The United States, particularly the south," writes De Saussure. He records specimens from New York, Illinois, Kansas, and Tennessee. Both Hartman and Cameron have recorded specimens taken in Texas.

O. annulatus Say.

A. annulatus Say; Long's Sec. Exp., Append. 29, II, 348.
Rhynchium annulatum Say; Bost. Journ. I (1837), 351, 4.
O. bairdi Sauss.; Revue Zoöl. X; 1858.
O. annulatus Sauss.; Syn. Am. Wasps Sol., 273-27; 1875.

♀. Total length, 12 mm.; wing, 10 mm.

♂. Total length, 10 mm.; wing, 8 mm.

♀. A medium-sized, rather slender, largely rufous wasp with coarse and dense punctures. This wasp closely resembles *O. arvensis* in form, from which it differs chiefly as follows: somewhat smaller and more slender; clypeus broadly pyriform but not as broad as that of *O. arvensis;* surface of clypeus simply punctate. Head rufous, except vertex, base of scape and flagellum, which are black; a spot on anterior portion of prothorax scutellum, a spot on scutum, tegulæ, yellow; rest of thorax rufous, except scutum and sides of mesothorax, which are black, and a spot below tegulæ, postscutellum, and a spot one each side on the metathorax above, and sometimes the anterior margin of the prothorax, part of the tegulæ and spots on the scutellum, which are yellow; usually there is a rufous spot in middle of scutum. Abdominal segments rufous, 1-5 bordered with yellow, the first having its border widened on each side, usually extending forward to the anterior margin of the segment; yellow maculæ on sides of second segment; often a black spot on the middle of the dorsum at the base of each segment. Legs rufous. Wings light smoky.

♂. Clypeus broader than high, more regularly octagonal; its anterior margin straight, having two distinct teeth on either side. Mandibles, clypeus, a triangle on the forehead, and a sinus of the eyes, a line on the scape, bright yellow; hook of the antennæ and postocular spots rufous. Otherwise as female.

This species is very variable in size and in coloration. I have specimens that measure 15 mm. in length. In coloration the Kansas forms vary particularly in the amount of black on the abdomen. In many specimens the black entirely replaces rufous on the third and following abdominal segments. De Saussure describes three varieties—a "black variety," a "rufous variety," and a "Mexican variety" in which yellow predominates. The Kansas forms are nearly like the "rufous variety."

Habitat: According to De Saussure, this species is found on the

prairies from Missouri to Texas, in New Mexico and the Mexican Cordilleras. In the Snow collections are also many specimens from Arizona and Kansas. Cameron reports specimens taken from Colorado.

O. dorsalis Fabricus.

Vespa dorsalis Fabr.; Syst. Ent., 367, 25; 1775.
Polistes dorsalis Fabr.; Syst. Piez., 273, 19.
Rhynchium balteatum Say; Bost. Jour. I (1837), 383, 1.
Monobia sylvatica Sauss.; Et Vespid. III, 168.
Rhynchium louisianum Sauss.; Et Vespid. I, 106, 7; 1852.
Rhynchium dorsale Sauss.; Et Vespid. III, 171.
O. dorsalis Sauss.; Syn. Am. Wasps Sol., 257-260; 1875.

♀. Total length, 17 mm.; wing, 14 mm.

♂. Total length, 15 mm.; wing, 12 mm.

♀. Large brownish wasp, ornamented with yellow. Clypeus a little wider than high, subpyriform; anterior margin truncate or even a little rounded, finely punctate. Head and thorax densely, strongly punctate; prothorax retracted anteriorly; postscutellum truncate, bearing a crenulation interrupted in the middle; metathorax rugose upon its borders, quite variable, according to specimens; its hinder plate flattened, striate, forming on each side a dentiform angle (at times blunted); its superior borders sometimes quite trenchant, sometimes effaced. Abdomen wide, conical; the first segment truncate apically, but rounded basally; the second finely punctured, offering along its posterior margin a wide rugose band, a little depressed, garnished with coarse punctures; this band a little widened in the middle; the very margin is smooth; the following segments are strongly punctured with the extreme margin smooth.

"Rufous Variety.—The whole insect rufoferruginous, except scape beneath, middle of prothorax, tegulæ, a line in the postscutellum, border of the first segment of the abdomen, yellow; feet mostly yellow; the flagellum of the antennæ black.

"Black Variety.—Insect black; mouth, clypeus, a spot behind each eye, articles one to three of the antennæ, rufous; prothorax, tegulæ, scutel, equally rufous"; yellow ornamentation as on rufous variety; "legs black; knees, tibia and tarsi yellow. Wings of a deep brown violet."

These two varieties are described by De Saussure, from whom I have taken the descriptions bodily. Both varieties and every gradation between them is found in western Kansas. The rufous variety is much the better represented of the two.

♂. Smaller. Clypeus as long as wide. Metathorax less blunted on the laterosuperior borders of the concavity, the superior edges more elevated, forming lines of salient rugosity, and separated from the postscutellum on each side by a fissure. Abdomen more conical; border of second abdominal segment deeply channeled and rugose. Clypeus, mandibles, inner borders of orbits, spot on the frons, a line on the scape of the antennæ, borders of abdominal segments 2-4, yellow. Wings not so deeply colored as in female. Otherwise marked as female.

Habitat: According to De Saussure, this species inhabits "the United States, especially the south." He records specimens from Pennsylvania, Illinois, Tennessee, Louisiana, South Carolina, and Mexico. In the Snow collections are specimens from Kansas and Texas.

O. hildagi Sauss.

O. hildagi Sauss.; Rev. et Mag. de Zoöl. IX, (1857), 275.
O. hildagi Sauss.; Syn. Am. Wasps Sol., 252-254; 1875.

♀. Total length, 13-14 mm.; wing, 10-11 mm.

♂. Total length, 11 mm.; wing, 8 mm.

A medium-sized, rufous, black and yellow wasp.

♀. The following description is taken directly from De Saussure, with two slight omissions: Clypeus punctured, widely truncate, its inferior part rather flattened and laterally bicarinate. Thorax in the form of an elongate square, not contracted posteriorly, densely and coarsely punctured. Postscutel sharply truncate, strongly crenulate. Metathorax very rough in its superior lateral face, its posterior concavity strigose, shining; margined with sharp edges, which form on each side a very strong dentiform angle, and which terminates superiorly in two eminences separated from the postscutel by deep fissures. Abdomen silky, quite conical, not ovate; its first segment large, as wide as the second, sharply truncate anteriorly, the margin of the second and following segments quite coarsely cribrose; the border of the second and third segments reflexed. Insect rufous and black and yellow, head black; mandibles, clypeus, margins of the orbits entirely or interrupted at the vertex, a spot on the forehead, and at the base of the antennæ rufous; mesonotum black; prothorax, scutellum, metathorax and tegulæ rufous; anterior margin of prothorax and a spot below the tegulæ refous or yellow. Abdomen rufous, all segments margined with yellow; the margin of the first segment widened at the base; triangular black spots at the base of the first and second segments; on second this spot is very large, sometimes covering half of the dorsal surface.

♂. Clypeus octagonal. Mandibles, orbits, a triangular spot on the forehead, a line on the scape of the antennæ, yellow. Margin of prothorax, scutel, a spot under the base of wing, and tibia, often yellow.

Habitat: De Saussure records species from New York, Louisiana, and Mexico. In the Snow collections are specimens from Kansas, New Mexico, and Arizona.

O. papagorum Vier.

O. papagorum Vier; Trans. Am. Ent. 88, 394-395; 1907.

♀. Total length, 9 mm.; wing, 7.5 mm.

♂. Total length, 8 mm.; wing, 7 mm.

A small black wasp, ornamented with yellow.

♀. Clypeus pyriform, terminated apically by a very small concave edge, rather coarsely punctured. Thorax elongate; metathorax narrowed; its concavity strigate-punctate; its superior lateral margins effaced by punctations. Abdomen ovate; the first segment subcampanulate, much narrower than second segment; cell segment punctate, most coarsely on borders. Black. The following yellow: edges of the clypeus except a break laterally on each side, a frontal spot, a mark immediately above the insertion of the antennæ, a mark in the emargination of the eyes, a postocular line, the anterior border of the pronotum, a spot below the tegulæ, a dot near the posterior margin of the scutum, postscutellum,

superior lateral edges of the concavity of the metathorax, posterior borders of all abdominal segments, and a spot on each side of the second abdominal segment. Wings subhyaline, deepened to fuscous in cells along anterior edge; interior and middle femora black, brown and luteous, posterior femora black and brown; tibia and tarsi reddish brown; middle and posterior tibia ornamented with a luteous strip on external aspect.

♂. Smaller. Clypeus polygonal, deeply emarginate anteriorly, finely punctured, a supraclypeal mark extending to posterior margin of the clypeus, and middle and posterior coxæ or a spot on those coxæ, yellow.

Types ♀ and ♂ in Snow collections. This museum possesses specimens from Kansas and Arizona.

O. sulfuritinctus Vier.

O. sulfuritinctus Vier; Trans. Am. Ent., 88, 389-390; 1907.

♀. Total length, 13 mm.; wing, 11.5 mm.

♂. Total length, 10 mm.; wing, 10 mm.

A medium-sized black wasp, much ornamented with yellow.

♀. Clypeus pyriform, longer than wide, anterior edge emarginate. Thorax elongate, narrowed behind; the concavity of the metathorax striate, its lateral margins forming on each side a dentiform angle. Abdomen ovate; first segment half as long as second; second segment reflexed. Entire body distinctly and densely punctate; punctures finest on first abdominal segment and base of second segment. Wasp covered with sparse golden pubescence. Black. Yellow confined as follows: a line on the basal half of the mandibles, clypeus excepting the margins of the anterior half and a triangular space in the middle, a spot between the insertion of the antennæ, the anterior aspect of the scape, a postocular spot; on the thorax a wide anterior border of the prothorax, portion of the tegulæ, a spot below the tegulæ, postscutellum, a spot on the superior lateral margins of the concavity of the metathorax; on the abdomen, all segments broadly bordered apically with yellow, this border continuing laterally, on the first and second segments, to basal margins of the segment. Coxæ and base of femora black; apical end of femora and tibia yellow; tarsi yellowish, with tendency toward brownish, especially in posterior pair. Wings brownish with yellow reflections.

♂. Smaller. Differs from female as follows: clypeus entirely yellow, no yellow marks in metathorax; yellow marks on anterior coxæ; tibia and tarsi more brownish than yellow.

Types ♀ and ♂ in Snow collections, University of Kansas.

Habitat: The museum possesses specimens from Kansas and Arizona.

Eumenes bolli Cress.

E. bolli Cress.; Hymenoptera Texana, Trans. Am. Ent., 4; 1872.

♀. Total length, 15 to 17 mm.; wing, 13 mm.

♂. Total length, 13 mm.; wing, 11 mm.

♀. Clypeus octagonal; the anterior side deeply emarginate, terminating on each side in two teeth, the parallel lateral sides with the anterior oblique sides forming dentiform angles; surface convex, finely punctured. A short but prominent carina between the antennæ. Head and thorax

coarsely punctured; posterior margin of scutellum convex. Petiole lengthened, pyriform; finely punctate; a medium furrow at apical end; second abdominal segment globose, densely punctate, with circular depression at the apical middle. Clothed with a short, dense yellow pubescence. Head black. Clypeus, labrum, a spot between the antennæ, a line in the emargination of the eyes, a postocular line, yellow; mandibles fulvous; antennæ with scape and two or three basal points of the flagellum rufofulvous; prothorax yellow ferruginous, more or less yellowish in front; mesothorax black, sometimes tinged laterally with ferruginous; scutellum ferruginous, black posteriorly; postscutellum yellow; metathorax yellow ferruginous, black on basal middle to apex; pleuræ ferruginous with anterior and posterior margins black; petiole ferruginous, basal half with a broad median black stripe, sometimes nearly as wide as the dorsum; second segment yellow, with a large blackish angular band, sometimes quite broad, starting from the basal middle and forking posteriorly at about the basal third, reaching the lateral margin at the apex; remaining segments ferruginous, tinged with yellow above. Legs yellow ferruginous; wings brownish with yellowish reflections.

♂. Smaller, less robust; clypeus narrower; third and following segments black, banded with yellow.

Habitat: Texas and Kansas.

Eumenes fraternus Say.

E. fraterna Say; Long's Sec. Exped., II, 344 (Append. 77); 1825.
E. fervens Sauss.; Vespides I, 40, 15; 1852.
E. mœrops Sauss.; ibid. I, 41, 18 (var.?); 1852.
E. minuto Sauss.; ibid. I, 39, 14 (Syn. exclus.).
E. fraternus Sauss.; Syn. Am. Wasps Sol., 95-98; 1875.

♀. Total length, 17 mm.; wing, 12 mm.
♂. Total length, 12 mm.

♀. In form resembling *E. bolli*. Longer and more slender. Clypeus less deeply emarginate; petiole longer at second segment, more gradually globose, flat underneath, very convex above, finely punctured, its posterior border with double leaves. All the body covered with short gray pile. Insect shining black; two oblique spots on the basal margin of the clypeus, the carina between the antennæ, a postocular spot, a spot on the anterior aspect of the scape, anterior border of the prothorax, postscutellum, a spot under the tegulæ, a spot on each side of the postscutellum on the summit of the metathorax, apical margins of first and second and sometimes third and fourth abdominal segments, and a variable dot on each side of the second abdominal segment, creamy yellow. Legs black; tibia variable with creamy yellow; wings brownish with violet reflections.

♂. Clypeus deeply emarginate, narrower than that of female; entirely cream yellow or with black dot in middle; scape of antennæ marked with a yellow line; hook of antennæ ferruginous.

Habitat: "The eastern part of the United States," writes De Saussure. "Very common." De Saussure records specimens from Louisiana, South Carolina, New York, Tennessee, Wisconsin, Pennsylvania, Illinois,

and Connecticut. Ashmead records having found it in Florida, and Harris in Massachusetts. In the Snow collections of Kansas University all the specimens are from Kansas.

Pterochilus 5-faciatus Say.

Pt. 5-faciatus Say; Long's Exp. to Sources of the St. Pet. Riv., II, Supp. 70; 1824.

Rhynchium 5-faciatiam Say; Bost. Jour. I (1837), 385.

Pt. 5-faciatus Sauss.; Syn. Am. Wasps Sol., 371-372; 1875.

♀. Total length, 17 mm.; wing, 15 mm.

♂. Total length, 12 mm.; wing, 11 mm.

♀. Mandibles large, armed with four lobiform teeth besides apical point, their external sides strongly ciliated with long hair. Clypeus transverse, sparsely punctate; posteriorly convex; somewhat produced in the middle; anteriorly rapidly narrowing toward apex, which is deeply emarginate; points of emargination toothed. Whole body punctate; head and thorax densely so; basal halves of first and second abdominal segments finely and sparsely, punctations increasing in density and coarseness toward distal margins of the segments; pygidium densely punctate. Thorax globular. Abdomen ovate, subsessile; second segment with a transverse carina at the base. Apical segments of the abdomen, posterior edges of tibia, and tarsi covered with sparse light brown pubescence. Black; strikingly marked with ferruginous and yellow. Head black, except mandibles, clypeus, first and second joints of antennæ and a postocular spot, ferruginous. Thorax black, except prothorax, tegulæ, a spot on the anterior margin of the scutum, sides of metathorax, lateral margins of its concavity, and sometimes a spot below the tegulæ, ferruginous; two large spots on scutum, the postscutellum, and sometimes a spot under the tegulæ, yellow. All the abdominal segments broadly margined with yellow. First abdominal segment ferruginous, with a wide black line along the center of the dorsum; second segment black with large ferruginous spots, sometimes touching the anterior margin, on either side. The remaining segments black. Wings smoky. Coxæ sometimes black; otherwise the legs are ferruginous.

♂. Smaller. Clypeus hexagonal, seven-sided, the anterior side deeply notched; widest anteriorly; yellow. Anterior margin of prothorax, a spot below the tegulæ, and a postocular line, yellow. On the first abdominal segment there is a small yellow spot in the large furruginous spot on the sides.

Habitat: Kansas, Missouri, and Texas.

THE FIELD OF OBSERVATION.

The observation and collections upon which this paper is based were made, as I have previously stated, in twelve counties of northwestern Kansas, in connection with the Biological Survey of the University of Kansas. The survey was made under the direction of Prof. S. J. Hunter. Mr. Francis X.

Williams was the head of the expedition. The party consisted of four men, besides the chief, all graduate students in the department of entomology.

The purpose of the survey was to study insect distribution in the territory covered and to add to the Snow entomological collections in the Museum of Natural History at the University of Kansas. This plan necessitated that the major portion of the time should be spent in general collection. However, whenever a eumenid colony or a single nest was located, I was given all the time necessary to devote to the study of the wasp's activities. Many nests, which I would not have otherwise had opportunity to observe, were first located by Mr. Williams, who directed me to them. He also made many helpful suggestions regarding my observations and the method of conducting them. All the eumenids collected on the trip were placed in my charge, in order that I might have sufficient material for a systematic study of the group.

The counties covered by the survey are included by an almost square area, occupying the eastern half of the northwestern quarter of the state. About one week was spent in each county. Camp was pitched, generally in some central point near a stream, and from this center radiated the daily collecting trips. Eumenidæ was collected in every county but one—Barton.

The itinerary in detail was as follows: Barton county, June 19 to 25; camp near Great Bend, on the Arkansas river. Rush county, June 25 to July 2; camp near Rush Center, on Walnut creek. Ness county, July 2 to 9; camp near Ness City, on Walnut creek. Trego county, July 9 to 16; camp in southern part of county, on the Smoky Hill river. Ellis county, July 16 to 23; camp near Hays, on Big creek. Russell county, July 23 to 31; camp near Russell, on the Saline river. Osborne county, July 31 to August 6; camp near Osborne, on the south fork of the Solomon river. Rooks county, August 6 to 13; camp near Stockton, on the south fork of the Solomon river. Graham county, August 13 to 20; camp near Hill City, on the south fork of the Solomon river. Norton county, August 20 to 27; camp near Lenora, on the north fork of the Solomon river. Phillips county, August 27 to September 2; camp near Kirwin, on the north fork of the Solomon river. Smith county, September 2 to 6; camp near Smith Center, on Rock Island lake.

Most of the land on which we collected, except in the river bottoms, was rolling. In Trego, Russell and Rooks counties it was very hilly, with many prominent stone outcrops. Along the rivers in those counties were cliffs varying from 80 to 150 feet in height.

Except along watercourses and around dwellings, the country had little timber. Even in the former situation the timber was either sparse, or a narrow strip, sometimes 100 yards wide, along the stream. The amount of virgin soil varied in the different situations from 25 to 90 per cent.

The season was unusually humid for that part of Kansas. It rained at least once during every week but two while we were in the field.

Odynerus papagorum Viereck.

Edges of streams and pools and the sunny sides of high cliffs are the situations in which I found wasps of this species most easily. I first noticed them at a cattle crossing on a creek. Coming and going continuously, each wasp, no doubt, made many trips a day to that stream for its load of water. Some of this activity, I later found, was centered in home-building in the side of a clay bank. I also soon learned to find them hunting on the heads of the sunflower and gaillardia—the feeding ground of their caterpillar prey.

I collected wasps of this species in five counties, and found their nests in four of them. When in Ness county, from July 2 to July 9, these wasps were abundant, and the nesting season seemed to be at its height. Hundreds of them were at work there in the high banks of light earth. It was in that place that I gave the most time to observing this species. The first colonies found were near Rush Center, in the banks of Walnut creek, on June 28. In Ellis county, from July 16 to 23, and in Osborne county, from July 31 to August 6, I found a few old nests and took a few specimens, but no nest-building was in progress. A few specimens were also taken in Trego county, from July 7 to 16.

Along Walnut creek, near Ness City, in a bank rising about thirty feet above the water, was the favorite nesting site of *O. papagorum*. The lower half of the bank was sloping talus; the upper half was practically perpendicular. In this upper half the nests were excavated. Most of these were at least three feet above the talus, although occasionally I found nests

within a foot of it. I did not observe a single nest within four feet of the top of the cliff. Perhaps the deep roots of the prairie grass interfered with digging there. All of the colonies were situated along western or southwestern exposures. There were other cliffs facing north and east, apparently exactly like those facing west, but, I believe, without a single nest. A bank in which there was much clay seemed to be avoided, although I did find a few nests in very hard clay. I did not find a single one in banks that were shaded by trees.

In choosing a location on the face of the cliff many wasps seemed to prefer a partially sheltered place. Little earthen ledges which protruded an inch or more sheltered many entrances to burrows. A crevice or a hole in the face of the cliff often had one or two nests near its outer edge. Even in the sides of the deserted burrows of the large digger bee, *Anthrophora occidentalis,* some of these wasps excavated their homes.

Two colonies were located on Walnut creek, in Rush county. One colony with about twenty nests was in a sunny, west-fronting cliff along the creek. All the nests were below the sod root line. The cliff was similar in both appearance and in character of earth to the favored nesting site in Ness county, The other colony was located in an artificial bank at the entrance of a dugout cave near the creek. This colony was from three and a half to five feet above the ground, and the highest nests were two feet from the top of the bank.

In Osborne county only small colonies—the largest had only seven nests—were noted. This was in spite of the fact that the cliffs which furnished nesting sites were similar in appearance to those in Ness county. They differed from that favorite nesting site, in that the earth at Osborne was much more sandy. Also, as far as I observed, these banks were always shaded by trees, except on a few north exposures. It was in these unshaded places that I found the colonies.

In Ellis county I found the remains of an old colony—four tubes over empty burrows—in the sides of a pit. They were about two feet from the surface and were on the side facing east.

The home of *O. papagorum,* as previously stated, is excavated in the face of an earthen bank. Excavated larval cells are connected with each other and the outside world by a burrow. These cells do not always open directly into the burrow,

but are sometimes arranged in galleries, the lower cells opening into the upper. Over the entrance of this nest is built a fragile earthen tube, in diameter about one-eighth of an inch, the same as that of the burrow, and in length varying from one-fourth of an inch to two inches.

The number of cells to a nest, in those which I investigated, varied from one to fourteen. In Rush county, among eleven nests the average number of cells per nest was a fraction less than four. The largest number of cells to a single nest found there was eight. In Ness county the average number of cells per nest, among sixteen nests opened, was six. There I found one nest with fourteen cells and another with ten cells. There were no others with more than eight. At Osborne the average among the four nests excavated was three. Of all the nests excavated during the entire summer I found but three with only one cell.

In the larger nests the cells were invariably arranged in galleries. The average number of cells to a gallery was between two and three. Of all the nests that I opened I found but one gallery with four cells.

The burrow led into the bank either in a horizontal direction or pointing downward; it never pointed upward. At various distances from the entrance, from one-half inch to five inches, there were openings from the main burrow into cells or into branch burrows leading to cells.

There was little uniformity in the arrangement of the cells. Yet I have found a number of nests in which symmetry prevailed. This was the case in the largest nest that I found, one with fourteen cells. These were arranged in seven galleries of two cells each. The burrow terminated in one gallery. The other six galleries were arranged in pairs at intervals along the burrow. On the other hand, I found many nests in which all the cells came from the same side of the burrow. Still other nests had a varying number of cells to the gallery.

The size and shape of the cells was nearly uniform in all that I measured. They were barrel-shaped excavations five-sixteenths of an inch in diameter. The long axis of these cells generally pointed downward. In 20 per cent of the cells that I noted the long axes were nearer horizontal than vertical. In a few cases the long axis was actually horizontal.

The burrow and the entrances to the cells were about one-eighth of an inch in diameter. The burrow was just big enough

for the wasp to enter, but did not permit its turning around while in the nest. The length of the burrow varied greatly, from one-fourth of an inch to five inches. The average distance for the first entrances to cells to the opening into the burrow was one and three-sixteenths inches. In one case which I noted the burrow opened into the first cell within one-fourth of an inch of the outer entrance.

The earthen walls of the cells and burrows were packed and smooth. They were always harder than the surrounding earth, forming a layer distinct from it, due to the fact that water, and perhaps saliva, was applied to them.

Earthen tubes projecting from the face of a bank over the entrances of burrows attracted my attention to the first *Odynerus* colony that I ever observed. These tubes were small and fragile, being only about one-fourth of an inch in diameter, inside measurement. In length they varied from one-fourth of an inch to nearly two inches. Most of those over one-half inch in length curved downward at the distal end. In texture the tube appeared to be made of a network of earthen cords, which were laid close together longitudinally, and with enough wide crossbands to hold them together. I did not note a single tube in which the direction of the strands of network were much longer at the distal end of the tube than near the basal end. At the base the tube walls were solid or with only very small openings. The width of the spaces at the distal end of the tube was about the same as the width of the earthen cords.

In spite of the apparent fragility of these tubes, they were quite durable when exposed only to natural conditions. While they were so brittle that I had difficulty in removing them from the bank with a pair of tweezers without breaking them, yet rain and wind appeared to have little effect upon them. I have excavated nests in which all the cells were empty except for pupal skins, and over some of these burrows were tubes one and one-half inches long. They had been built at least a month before, probably much longer than that, and had been exposed to several rains. The rains left no record of the percentage of tubes they may have destroyed. The fact that the wasps often select sheltered spots as nesting sites indicates that the weather may affect the durability of the tube. Yet I believe that many of these tubes endure for longer than the nest has inhabitants, and far longer than their fragile appearance would warrant. This durability is due, I believe, as

Sharp suggests regarding *Eumenes,* to saliva or some other buccal secretion which the wasp may mix with the earth and water during the construction of the tube.

One purpose of this tube, as has been suggested by Messrs. Hungerford and Williams regarding the tube of *O. annultatus,* is to hinder parasites from finding the entrance to the burrow. I shall discuss this in my notes on parasites.

The very beginning of nest-building—that is, the location of the site—I observed but once, in Ness county. Here a wasp was walking rapidly back and forth on the face of the cliff, covering an area of a few square inches. Occasionally she would stop and test the surface with her mandibles. After two or three minutes of this surveying she took wing and zigzagged up and down a few inches in front of the area over which she had been running. She alighted, then repeated the uncertain flight in front of the cliff, and again alighted in the same place. Again she took wing, this time making a few large zigzag circles before the face of the cliff, and then flying away.

I had watched her performance with curiosity, but did not realize its importance until she had returned a minute later with water. She flew almost directly to the place she had so carefully surveyed, wet a spot, and began digging.

O. papagorum dug rapidly both with her mandibles and her fore feet, pulling the moist earth to the edge of the burrow, and there pressing it against the bank, making a thick foundation for the tube wall. While her head and fore legs were constantly at work within the burrow, the rest of her body also was in motion, swinging around the burrow entrance. At one instant the wasp was facing the lower side of the burrow; the next instant she might have changed her position so as to be facing the opposite way. The burrow was an axis about which the wasp's body swung back and forth.

Soon the tube became so long that it was impossible to pull the earth to its edge without backing out. Then Mrs. Wasp began to form the excavated earth into pellets, which she carried out in her mandibles to add to the length of the tube. She would then press the tip of her abdomen against the outside of the tube while she worked with her fore feet and mandibles within.

After she had been digging for three and one-half minutes she went for more water. This trip occupied forty seconds.

The next three successive trips for water were made at intervals of approximately four minutes each.

After fifteen minutes' work the wasp was completely hidden in the tube when digging. After fifty minutes the tube was one and one-fourth inches long, and near the tip it was curved downward. She then began discarding the excavated pellets, no longer using them to add to the tube. She would back out of the tube with the pellet in her mandibles, poise on wing a moment, just long enough to drop the pellet, then she would reenter at once. When she began dropping the pellets I supposed that the tube-building was finished. However, when I returned, within only two hours after the excavations had been started, the tube was two inches long. At this time it was finished, I believe.

I left her then, still dropping pellets. She had begun digging at 2:30 P. M. July 5. The next morning when I took my place before the cliff she was provisioning her nest with caterpillars. But the nest-building had not been completed, for in the afternoon of July 6 she was again excavating, probably adding more rooms to her house.

I have observed many of these wasps at work on their nests; a few of them I noted when the excavation began; and the routine of work—the method of digging, the building of the tube, the dropping of pellets, and the occasional trip for water—was essentially the same.

There was little regularity about when time should be spent on tube-building. The tube was always started at the beginning of the work. Often it was finished before any of the pellets of earth excavated from the burrow were thrown away. On the other hand, I have noted a number of instances in which the tube was scarcely more than started when building it further seemed to be abandoned; the excavated earth was discarded. After one or two cells had been dug and provisioned, work on the tube would again begin.

Earth used in tube-building, as I have stated previously, is usually excavated from the burrow. There are rare instances, however, in which this is not the case. I noted one wasp discard most of the earth taken from her burrow one afternoon. The next afternoon she laboriously collected particles of earth from the side of the bank several feet below her nest with which to lengthen her tube. I noted another wasp set about lengthening her tube after she had wasted much soft earth

excavated from her burrow. This wasp was less scrupulous than the one just mentioned, for she stole soft earth freshly excavated from its burrow from the tube of a neighbor—the digger bee, *Anthrophora occidentalis*. These cases, of course, are exceptional, for such poor economy is rare among the *Odyneri*.

When the nest has been provisioned its entrance is sealed with mud. There seems to be no rule as to exactly where it shall be. Of eight closed nests that I investigated in Rush county, three were sealed in the basal end of the tube at the entrance to the burrow; two others were only at the distal end; the remaining three were in two places, both at the distal and basal ends of the tube. Earth for closing the nest was generally taken from the cliff near the nest.

In all their excavations and masonary these wasps use water. Even when collecting earth from the sides of cliffs to close their tubes they make frequent visits to streams.

After the excavation of the nest it is provisioned with food for the wasp grub. In all the nests that I opened a noctuid caterpillar, apparently of the group Heliothinæ, was used. The largest of these caterpillars that I took from nests were 13 mm. in length. Some were as short as 10 mm. Their dorsal color was dark red or reddish purple, with four longitudinal white stripes. Ventrally they were greenish or purplish white. I found this caterpillar feeding on the heads of several species of sunflower (*Helianthus* sp.), the gaillardia (*Gaillardia lutea*), and the purple cone-flower (*Brauneria purpurea*).

The number of caterpillars stored in each cell varied from five to ten. The average per cell in Rush county was a little more than seven caterpillars; in Ness county the average was nearly nine. According to these estimates, the average number of caterpillars that should have been stored in an average-sized Rush county nest is thirty. The average number of caterpillars in an average Ness county nest should have been fifty-four. The largest nest that I found—one with fourteen cells—should, according to the Ness county average, have contained 126 caterpillars.

The largest number of caterpillars that I actually found in a single nest was fifty. This nest had eight cells. In two of these cells there were no caterpillars, for the wasp grubs within were full grown. In another cell there were seven caterpillars and a small wasp grub. In the other cells the

wasps had not hatched, and consequently the larder remained untouched. Three of these cells contained eight caterpillars each, one contained nine, and another ten. The nest undoubtedly at one time had contained at least fifteen or twenty more caterpillars than it did at the time when I opened it.

Why should the average number of caterpillars per cell have been so much higher in Ness county than in Rush county? There were two conditions that may have affected this difference. The caterpillar prey was much more abundant in Ness county; so were the wasps. A more important item is, that the cells opened in Ness county which I could consider in this count were stored on an average a week later than those that had been in the same condition in Rush county, for any cell that had been stored more than three days before we opened it was likely to have its larder more or less depleted by the hungry wasp grub. The weather had been considerably warmer while we were in Ness county, and the activity of the wasps was correspondingly increased. This may also have been one reason for the larger number of cells in the nests in Ness county.

I noted these wasps frequently on their hunting ground—containing the food plants of their caterpillar prey. But in spite of the comparative abundance of both the wasps and the caterpillars, I saw the capturing of prey only twice. On one occasion a wasp seized a caterpillar near the anal end, and by repeated jerks pulled it from its hiding place between the disk flowers in the gaillardia head. When the caterpillar finally let go both rolled from the flower to a leaf below. For an instant they were out of my sight. When I saw them again the wasp was holding the caterpillar by the neck and was stinging it under the thorax. I noted two thrusts. Then the wasp quickly bestrode its prey and began maxalation. Some movement of mine must have disturbed the wasp, for it stopped suddenly, watched me for a moment, and then flew away, leaving its victim on the leaf. The caterpillar appeared to be dead, and did not respond to any irritation. Unfortunately I did not keep it to observe further developments.

On another occasion I noted a wasp on a sunflower astride a caterpillar and maxalating it. Then she turned the caterpillar ventral side up and continued chewing and twisting its neck; then she flew away with it.

When hunting, this wasp sometimes runs quite rapidly over the flower heads. More often her progress is very slow, as she peers carefully among the disk flowers.

I was anxious to observe the wasp's attack upon her prey more closely, and thought to bring this about by artificial means. With nails I pinned two sunflower heads in the midst of a colony. Upon these sunflowers I placed about a dozen caterpillars upon which *O. papagorum* preyed. There were the same species of caterpillars for which the wasps had been searching so diligently in the field, within a few inches of the thresholds of the wasps' storehouses; but my efforts were fruitless. Not a caterpillar was attacked. Not only did the wasps ignore the caterpillars I had placed there for their convenience, but they seemed even to be wholly unmindful of the sunflowers. They flew directly to and from their nests as if nothing had been changed in the site of their colony.

The caterpillar is carried ventral side upward. With her mandibles the wasp grasps the caterpillar's neck. One pair of legs are also used in holding the caterpillar's body under her own.

Upon reaching her nest, the wasp with her mandibles and legs quickly moves the caterpillar, head first and ventral side upward, into the tube. Then she follows it in. As far as I have observed, the wasp always pushes the caterpillar with her head. After the caterpillar is stored she backs out and again goes on the hunt.

Storing caterpillars was not always an easy matter. On one occasion I saw a wasp have considerable difficulty in pushing a caterpillar ahead of her into the tube. The caterpillar did not seem to be thoroughly paralyzed, for as soon as it was pushed ahead of the wasp it would try to curl up or hold to the sides of the tube. After several attempts the wasp started it into the burrow. About four minutes later she backed out, bringing the unruly caterpillar with her. She alighted on the side of the cliff and vigorously bit its neck and first thoracic segment. After belaboring it for about a minute she pushed it in again, this time with no apparent trouble.

Of all the caterpillars that I took from cells, not one that I noticed was dead. Even those that had been in cells so long that nearly all of their partners had been devoured by the wasp grub still responded to stimulation. The caterpillars were paralyzed with varying degrees of success. Some would only

move their abdominal segments when irritated, while others could make their way out of the cell after it had been opened. One caterpillar that I had seen captured in the field was apparently dead or totally paralyzed. This was the only exception. It has since occurred to me that this state may have been only temporary. *O. papagorum* may totally paralyze caterpillars when she captures them, thus making them more easily managed during the storing process. After it is stored the caterpillar may partially recover from the paralysis.

Most of the cells freshly stored were packed with a tangled mass of caterpillars. Usually there was no vacant space in the cell.

On removing the mass of caterpillars from the cell I often found the egg suspended from the roof of the cell by a white thread. It was not suspended above the caterpillars. As far as I observed, it was always in the part of the cell farthest from the entrance to the burrow. Sometimes it was attached to the roof at the lower end of the burrow, so that the egg was nearly in the bottom of the cell. In spite of the thread attachment, in most cells the caterpillars must have been fairly piled upon the egg.

Oviposition may take place before any caterpillars, or after only a few, are stored. The usual position of the egg would indicate that it was deposited at least before many caterpillars were stored. I did not open a single empty cell in which I found an egg. However, I did find eggs suspended in only partially stored cells; in one case the cell had but two caterpillars.

The length of time required to make and store a nest depends chiefly upon the number of its cells, and upon the weather. In cold, damp weather the wasps are very sluggish and work but little. Wind also has a discouraging effect upon work. On hot, sunny days they were most active. I noted one three-celled nest that was finished in two days. On the other hand, I opened larger nests which contained larvæ and pupæ of ages that must have been at least ten days or two weeks apart. The length of time required for nest-building also depends to a certain extent upon the individual wasp, as some are much faster workers than others. It is also difficult to make an estimate of the length of time required to store a cell, as I have found wasps with as many as three cells open at one time and storing caterpillars in all of them.

An extract from my field notes may show about how fast an average wasp works on a favorable day. It reads as follows: "*O. papagorum* left nest at 8:40 A. M. Returned in eleven minutes with a caterpillar. Storing it required three minutes. Returned with second caterpillar in twenty minutes. Stored it in five minutes. Hunt for third caterpillar took twenty-five minutes. Spent eight and one-half minutes storing it. Returned in fifty-three and one-half minutes. Stored it in three minutes. Came out and backed into tube (perhaps to oviposit). Stayed inside five minutes. Returned with caterpillar in twenty-six minutes. Storing it required thirteen minutes." Thus three hours and forty-five minutes were spent in capturing and storing five caterpillars.

The egg of *O. papagorum* is cylindrical, slightly tapering toward the rounded ends. It is creamy white in color. The filament attachment is white and about the same length as the egg. The egg is 2½ mm. long and ⅔ mm. in its greatest diameter.

The larva is a very stout grub, much larger posteriorly than anteriorly. Its ventral outline is slightly curved, and when mature is about 10 mm. in length. Its dorsal outline is strongly curved and is 13½ mm. in length. Its greatest diameter is 4½ mm. In color the grub is whitish. The pupa is also whitish, and is 9 to 10 mm. in length.

Closely associated with *O. papagorum* was a cuckoo bee, *Chrysis pattoni*. The green parasitic bees were ubiquitous on the faces of cliffs in which the wasps nested. They often seemed more numerous than the wasps themselves.

These chrysidids spent most of their time searching the face of the cliffs, investigating every hole or crevice in the bank, and sometimes finding their way into the tube of *O. papagorum*. These same cliffs were also used as nesting sites for small andrenid bees. While I seldom saw a cuckoo bee pass one of these burrows by without stopping to look into it, I never saw one actually enter an andrenid nest. They seemed to be searching for the storehouse of *Odynerus*.

The tube over the entrance to the burrow was of considerable importance, I believe, in keeping these undesirable guests out of the nest. Because of this tube, cuckoo bees seemed at least to have great difficulty in finding their way into the burrow. When a cuckoo bee would come in contact with a tube it would generally pass it by, while it would easily have found an open

burrow. However, when it found the entrance to the tube it would go in at once, even though the wasp might happen to be within the nest. In the latter case the chrysidid would come out in great haste.

On one occasion I saw this *Chrysis pattoni* break open a tube with its mandibles. The tube had been sealed the day before by the wasp. *Chrysis* did not try to break the tube at the base, where it was thickest, but at the distal end. I took *Chrysis* out of the nest after it had penetrated to the main burrow.

O. papagorum occasionally showed signs of hostility toward the cuckoo bee by darting at it when the latter was too near its nest. The cuckoo bee always made good its escape. It also showed signs of fear when it entered the wasp's nest and found the owner at home. Most of the time, however, each of these insects ignored the other's presence.

In spite of the abundance of this cuckoo bee, I found little evidence of parasites in any of the nests that I opened. Pupal cases, probably of some chrysidid, were sometimes found in nests. I found one nest with an unfamiliar grub in it feeding in the same cell with the *Odynerus* grub.

Joint proprietors with *O. papagorum* of the cliffs in which the large colonies were located were *Anthrophora occidentalis*, several andrenid bees, several species of philanthids, *Trypoxylon* sp., and *O. hildagi*. No advantages or disadvantages to *O. papagorum* seemed to result from this proximity of other insects except of *Anthrophora*. Twice I noted *Odynerus* taking mud from this bee's tube, and the vacated burrows of the bee sometimes furnished shelters for the bases of the tubes of *Odynerus*. Had they been more numerous, *O. hildagi* might have become a rival for food, as they preyed on the same caterpillars.

This wasp was strongly colonial in habit. It may have been due to a certain extent to the scarcity of ideal nesting sites. This does not seem to me to be sufficient explanation, however. In Rush county a colony was located on an earthen wall at the entrance of a dugout cave. This wall presented an area of bout thirty-five square feet, artificially made smooth. It was in one plane and all parts were almost equally exposed to the weather, as there were no ledges of earth for the protection of tubes to prejudice the location of a colony in a certain place. Yet a colony of ten nests was located on a space seven by

twenty-one inches. The great colony in the cliffs in Ness county was made up of many small colonies of twenty to thirty nests, while spaces between these colonies, which offered situations for nesting of essentially the same character, were untenanted.

I could not observe any advantage gained by this colonial habit. However, the wasps must have been influenced by each other, for there was a tendency in a colony for all to do the same kind of work at the same time. When I saw one wasp bring a caterpillar to her nest I knew that the rest of the colony was probably also on a hunt. When I saw one wasp back out of her tube with a pellet of earth I expected to see others also, either excavating or otherwise engaged in nest-building.

The time of day also seemed to be a dividing factor in the kind of work *O. papagorum* would do. Mornings were generally spent hunting and storing caterpillars. Afternoons were generally given to nest-building.

O. papagorum began working between 7:30 and 8 A. M. during my stay in Ness county. She began hunting at once in earnest, in contrast to some other *Odyneri* who would work only in a desultory way until the morning was half gone. Late in the afternoon some of these wasps would quit working. Others I noted were still busy just before sunset. The night was spent in the nest.

During the busy season these wasps must make many trips a day for water. Their familiarity with water does not make them incautious about approaching it. Sometimes they will alight upon still water, in tanks, pools, or in tracks beside streams, but I have never seen them alight upon running water, or even float upon it. When taking water from streams they alight at the water's edge. Often they will take water from the wet sand at the edge of a stream.

When *O. papagorum* alights on water or on the side of a cliff, or when hunting on a flower head, it always keeps its wings spread and held up obliquely from the thorax, thus constantly keeping them in a position to take flight at any time. This is characteristic of all the *Odyneri* that I have observed.

On their homecomings these wasps always, if undisturbed, flew directly to their tubes, paying no attention to the tubes of others in the colony. Was this due to a sense of direction or to a memory of the nest's surroundings? I had noted a wasp

making a zigzag flight before a small area in the face of the cliff in which she located her nest. This zizgzag flight I had supposed was a "locality study," to aid the wasp in finding the exact spot again. This idea I owed to a suggestion from the Peckhams; I considered it analogous to the many locality studies they had observed.

When I pinned two sunflower heads on the face of the cliff in the midst of a colony, as I have previously described, and the wasps absolutely ignored these decorations, my confidence in their observational ability was shaken. The wasps flew directly to their tubes as if there had been no change in the appearance of the side of the colony.

That afternoon I purposely knocked off two long tubes when the owners of the nests were away. When the wasps returned they flew without the slightest hesitation directly into their uncovered burrows. I went to another colony and paritally mutilated three other nests by knocking off the tubes and cutting out a part of the burrow, and then with my knife I made gashes in the bank for several inches around the entrances of these nests. Two of the wasps flew directly to their burrows and entered as usual. The other wasp lit a few inches at the side of the burrow, hesitated a moment, and then walked directly into it. When observing these wasps they seldom seemed to resent my presence. Usually they did not appear to notice me at all.

These wasps whose homes I had mutilated were not blindly unaware of the change. At the time I broke the tubes the wasps were enlarging their respective burrows. Apparently the tubes were finished. But within ten minutes after I had broken the tubes all of the wasps were building new ones. Only one of them began work on the new tube at once; all of the others continued discarding their excavated pellets for several minutes. All three of the wasps whose nests I had mutilated with my knife inspected by depredations several times before beginning the rebuilding of the tube.

The effect of a strong wind upon the work of these wasps I had opportunity to observe on the afternoon of July 4. A gale was blowing furiously from the southwest, striking diagonally the face of the cliff in which the *Odynerus* colonies were located. The temperature was high, as usual, and ordinarily I would have expected to see the colonies very active.

For two hours I stationed myself in front of a small colony of eight burrows. During that time I saw five of the owners of these burrows.

The first wasp came from the field unburdened, and entered its tube. In two minutes it came out and backed in. It stayed in this position for forty-three minutes, although three times it showed its head at the entrance of the tube. At last it came out, but reëntered at once head first. Eight minutes later it again came out and backed into the nest. The rest of the time I was there it occasionally showed its head at the entrance of the tube, but never ventured out.

The second wasp came home with a caterpillar. She had difficulty in alighting, for several times as she poised to grasp the tube with her feet the wind would dash her against the cliff. When at last she was successful in alighting she had difficulty in pushing the caterpillar ahead of her. Ten minutes later she came out of the tube and backed in. Twice after that she showed herself at the entrance, in thirty-seven minutes after she had backed into the tube, and again ten minutes later.

Wasp number three stayed at home all afternoon. Once she showed her head at the entrance.

The fourth wasp was excavating when I arrived. She would drop a pellet about every thirty seconds. After bringing out six or seven pellets she would go for water and battle with the wind on her return. Only twice she made the trip without mishap. Usually when she was about to alight the wind would dash her against the cliff, sometimes apparently causing her to lose her load of water, for she would again fly to the creek. After working in this way for thirty-five minutes she backed into her tube to stay, although she showed herself at least two times.

The fifth wasp tried to work the whole afternoon in spite of the gale. For some reason she was collecting earth from the side of the cliff and carrying it into her nest a few feet away, perhaps to seal some cells. She was very unsuccessful in her work, for nearly every time she would try to alight on the end of her tube she would lose her poise, be blown against the cliff, and would drop her load of earth. She would then go back for another. When I first noted her she would gather a load of earth in her mandibles and fly to the tube, approxi-

mately every fifty seconds. Later in the afternoon she was much slower. She was collecting earth when I first observed her, and made seven attempts before she succeeded in alighting with her load. She backed out part way in seven minutes, then disappeared again. Five minutes later she came out and started for a second load of earth. In four minutes she succeeded in alighting with a load. She came out and backed in. Six minutes later she again began work. It was fifteen minutes before she succeeded in landing. She remained in the nest only four minutes. The next successful trip required twenty minutes of struggle. When I left she was still battling with the wind.

Odynerus arvensis Saussure.

Odynerus arvensis is one of the most numerous of the eumenids in western Kansas. I collected it in every county covered by the survey, except the first one. It was common throughout the summer, being taken regularly between June 26 and September 6. It was most readily found in lowland fields and pastures or near water.

Along the edges of streams, throughout the entire summer, this wasp was by far the most conspicuous of the *Odyneri*. At crossings for live stock on streams, at the edges of sand or mud bars, where the insect can walk directly to the water's edge, I always expected to find an assemblage of these wasps. Where the approach to water in a stream was in any way abrupt I never found them; like *O. papagorum*, *O. arvensis* never floats on running water. However, they were common floating on water in cattle tracks at crossings or in small pools. At these situations wasps were constantly coming and going. They were the busy females getting water for nest-building.

On sandy beaches along watercourses I sometimes observed dozens of wasps, also of this species, apparently playing in the sunshine. In contrast to those just described, they seemed to have no particular business except to chase each other up and down the beach. They were very wary and active, like sand robber flies, and were hard to take with a net. I collected fourteen of these idlers one afternoon in Rooks county, and without exception they proved to be males. They could not have been waiting there for females to come for water, for nowhere along that sandy beach was there a place frequented

by females. I believe that males wait for females at the entrance of burrows when the latter are about to emerge. At any rate, one was brought to me by Mr. Mallory which he had taken waiting at the entrance of a burrow in which was a female almost ready to come out.

Both males and females of this species were frequent in lowland fields and pastures, but I seldom saw one on a hillside. In some places they were common on lamb's-quarter and croton plants. The former was the food plant of one of its caterpillar prey. The latter also may have been frequented for the same reason, but quite often I saw this wasp on the croton flower, apparently seeking nectar.

O. arvensis does not have the colonial nesting habit, nor does it favor one nesting site to the exclusion of all others, as does *O. papagorum*. Consequently its nests were less easily found and its habits not so readily studied.

O. arvensis, as I found her, was always a burrowing wasp. Her burrows were the least carefully made of the digging Eumenidæ that came under my observation. The variation that may occur in the nesting habits of a single species of wasp is here shown. This same species, when observed by Mr. Hartman in Texas, made her domicile in any convenient crevice in a wall or fence post.

An open space near water seemed to be the only characteristic common to all the nesting sites I observed. During the summer I noted eighteen nests in the course of construction or finished. Of these six were located in the talus at the base of cliffs along the edge of streams, two in moist flats within a few feet of the water's edge, five were in cow paths in pastures, three in open spaces in pastures, one in an open space in fallow land, and one other in the dry bed of an intermittent stream. One of these burrows opened in a short growth of grass, while the others were in spaces practically free from grass or weeds. One was located in a cow path running through a narrow strip of timber, while all the others were in sunny places. All the nests were within thirty yards of water but one, which was about a hundred yards from water. The character of the soil in which the nest was located seemed to be a matter of no consequence. There was every gradation from a hard clay mixed with limestone—so hard that I could scarcely dig into it with my knife—to the soft alluvial soil of the flats beside the streams.

Observations on nesting habits were made at intervals throughout the summer. Nests were noted in Rush and Ness counties; from July 16 to July 30 nests were found. None were found in the next three counties, but in the last three visited—Norton, Phillips, and Smith—from August 20 to September 6, nests were again located. Females were as numerous at a pool near Smith Center, September 3, as they had been at any place visited previously, indicating that the nesting season was still in full progress at that time.

The general direction of the digging of *O. arvensis*, whether she is working in level ground or in talus, is downward, and not horizontal like *O. papagorum*. At the bottom of her more or less vertical burrow are the larval cells. Over the entrance of the burrow is built a thick upright earthen tube.

Of all the nests that I observed, in only eight had the burrow been excavated as far as the brood cell when I opened it. Of these only two were entirely finished before I interrupted the process. These burrows ranged from three and one-half to seven inches deep. The average was five and one-fourth inches. The average diameter of the burrow was one-fourth of an inch. This long burrow was never absolutely straight.

The number of larval cells to a nest varies greatly. In six instances I found only one cell to the nest; in another instance I found three cells; in still another instance I found six cells.

Of those nests in which I found but one cell, only one burrow had been sealed by the wasp. Most of the others were still being stored with caterpillars, and might have had other cells added later. In two of these nests the cell was directly at the bottom of the burrow; in the other four the burrow made a sharp turn before entering the larval cell. All of these nests were situated in soil comparatively easy to dig in.

The nest with six cells was excavated in the hard clay talus at the base of cliffs along the Saline river. The cells were arranged in three galleries, two in each gallery, one cell being directly above the other. When I opened the nest five cells were closed and one was empty, serving as a hiding place for the mother wasp. The other nest consisted of three cells arranged one above the other. It too was in the clay talus. It was located by Mr. Mallory.

All but two of the cells in these nests were shaped like short cylinders with somewhat rounded ends. The diameter of these cells averaged one-half inch, and the length ranged from nine-

sixteenths to five-eighths of an inch. In two cases the cells were lengthened and the ends rounded to such an extent that they had the shape of ellipsoids.

The cells and burrows of *O. arvensis* were roughly excavated. The walls were packed a little, but are not always smooth as in the case of *O. papagorum.* They never formed a layer of earth around the nest distinct from the surrounding earth.

The tube which *O. arvensis* built over its nest was an erect, or bent, cylindrical, earthen chimney. In length it varied from one to one and one-fourth inches. The interior diameter of the tube at its base is about the same as that of the burrow, one-fourth of an inch. As the wall decreases in thickness toward the terminal end of the tube, these inside measurements of the tube grow larger. The tube has a substantial appearance. At the base the walls are about one-eighth of an inch in thickness. The tube wall is solid, not a network as the tube of *O. papagorum.* Its exterior has a granular appearance. The shorter tubes are generally straight, while the larger ones are bent.

In spite of its solid appearance, this tube is only a temporary structure. A light rain will dissolve it. If it escapes the rain, Mrs. Wasp tears it down when the nest is finished and stuffs it into the burrow. Thus the burrow, which could easily be betrayed by the large tube, is quite securely hidden. The tube is probably a temporary defense against parasites while the provisioning of the nest is in progress.

The nest-building I observed on five occasions, and in its very beginning twice. In a dry bed of an intermittent stream in Russell county, I noted a black *Odynerus* make a "locality study"—a few irregular circles over an area about eighteen inches in diameter—and then fly away. In less than two minutes she was digging in a spot over which she had been flying. She had moistened the spot and was working with her fore feet and mandibles. The excavated earth was used in tube-building. She worked much as did *O. papagorum,* putting the freshly excavated earth in place with her mandibles, then working with her mandibles and fore feet inside the tube, while the tip of her abdomen pressed against the outer wall. After the earth was in place she would quickly run down the burrow again for another load. Every three minutes, as regularly as if she had timed herself by a clock, she went to the

river for water. This trip took from one minute and forty seconds to two minutes. After the tube was half an inch high she began dropping pellets a few inches from the burrow.

I had watched her from 7:50 A. M. until 8:20 A. M. As I had other work for the morning, I left her. When I returned about noon she had deserted the nest. This observation was made July 24. The building of this nest was fairly typical, as far as I observed, of the nest-building of the species.

When the nest is stored the cells are sealed, the tube is torn down with the aid of several loads of water, and is tamped into the burrow. Loose earth around the burrow is also pushed into it until it is entirely filled. This process I observed but once.

Four species of caterpillars—three pyralids and one noctuid—were found in the nests of *O. arvensis* that I opened. I did not find more than a single species of caterpillar stored in one nest, or even taken in one locality. On the other hand, with each change of locality there was a change in the caterpillar prey. One of the caterpillars upon which this wasp preys, *Loxostege sticticalis,* is of considerable economic importance.

The caterpillars in every instance were alive in the nest when I opened it. *O. arvensis* was often very careless about the state of mobility in which she left her prey. Once several caterpillars actually climbed the sides of the glass vial in which I had collected them, worked their way through the cotton stopper, and were crawling actively about on the inside of my collecting bag.

All of the caterpillars which this wasp collected were rather slender. All were larger than the wasp, varying from 16 to 18 mm. I never found more than seven caterpillars in a cell.

A black *Odynerus* storing caterpillars in her nest I observed in Norton county, August 22. Mr. Williams had found this wasp's tube in a small open space on a fallow hillside, and called me to see it. I waited twenty-five minutes before the owner of the nest appeared with a caterpillar. She deposited it quickly, backed out of the nest, and again went to the field. In thirty-five minutes she returned with a second caterpillar. I then interrupted the proceedings by taking the wasp and opening the nest.

Her manner of entering the nest with the caterpillar differed somewhat from any of the others of this genus that I have observed. She flew to the tube and rushed into it at once,

dragging the caterpillar under her body, not stopping to push it ahead of her. Her method of carrying the caterpillar, its ventral side up, the wasp's mandibles grasping the caterpillar's neck, is similar to that of others of this genus. This was the only time that I observed the storing of caterpillars.

In this cell I found three very lively caterpillars. I also found an egg suspended from the cell roof, as far as possible from the entrance. Although this egg was suspended, it was hanging, not above the caterpillars, but among them. Had two or three more caterpillars been added they would have been piled above the egg. I assumed that in this case oviposition had taken place before the storing of the cell had begun. At least I had seen two of the three caterpillars stored, and oviposition had not taken place while I was there. I found the egg of this wasp on one other occasion. It was suspended from the roof of the cell as far as possible from the entrance. I had not seen the egg until several caterpillars had been removed, but the cell was so full that it must have hung among them. This cell had been fully stored before I found it.

This wasp may not always be active from the time her nest is begun until it is finished. The wasp with the celled nest, previously described, gave no sign of industry during the time I waited before her nest, which extended at intervals through three days. She visited the nest occasionally, but brought no load. On one occasion she started, apparently, to enlarge her nest, bringing out three pellets in one minute and forty seconds. After dropping the third pellet she flew away. When I opened the nest I found the wasp with her head in the entrance of the one empty unsealed cell.

The five closed cells were completely ravaged by a little brown ant (*Solinopsis* sp.). A few caterpillars' skins were left in one of the cells, but the others were empty except for the ants. This is the only suggestion of an insect foe of *O. arvensis* that I noted except a cuckoo bee that I dug out of a nest in Ness county. I was unable to take it, and so can not give the species.

As far as I observed, *O. arvensis* never had any trouble finding her way to her nest. She never seemed to be sensitive to observation.

Odynerus annulatus Say.

I found no general rendezvous for the workers of this species. This wasp is never found, unlike *O. arvensis* and *O. papagorum*, coming and going in considerable numbers for water to a particular mud bar or cattle crossing in a stream. *O. annulatus* is not usually cautious about approaching running water. Many times I have seen her alight fearlessly on a river roughened by the wind, and ride over a riffle without mishap. She can take water at almost any place along a stream. Why should she need a special watering place?

The males of this species, however, like the males of *O. arvensis*, do assemble for a dance in the sunshine. I noted this but once. On the west side of a stone outcrop, about fifty yards east of a small creek, was a long sand bank. Up and down this sand bank played a number of male wasps of this species. I collected six of them. This observation was made August 15, in Graham county.

This wasp was taken in all of the counties covered by the survey in which eumenids were collected. It was less numerous than *O. arvensis* and *O. dorsalis*. It appeared in greatest numbers in Trego and Graham counties, both in the western tier of counties covered. These counties, in the vicinity of our camps, were more nearly treeless than any others visited.

The variation of this wasp in nesting habits are as striking as its variations in color pattern. Sometimes she is a digger wasp, with a burrow and tube much like that of *O. arvensis*. Messrs. Hungerford and Williams described her as a builder of one-celled nests in open spaces in a prairie. I have found but three nests. One had three cells; it was dug through a sod, in an alluvial flood plain of a stream. Another had twenty-two cells; it was dug in a barren, hard clay talus at the base of a cliff. The third nest had been used previously by *Pelopeus* sp., and was appropriated by a lazy or economical member of this species. Because of the entirely different conditions connected with each of these nests I shall deal with each separately.

The wasp that used the old nest of *Pelopeus* I collected in Trego county, July 12. About 100 yards from the Smoky Hill river, near our camp, were chalk rock cliffs 110 feet high above the flood plain. In cavities of these rocks and under ledges were many nests of *Pelopeus*. While climbing among these rocks I saw a eumenid, which proved to be *O. annulatus*, carry-

ing a caterpillar into one of these nests. I could not climb up to the place, so I took the nest, wasp and all, in my net. She had stored five caterpillars in one cell. All the caterpillars were *Loxostege sticticalis*.

At the base of the cliffs in Ness county, in which this great colony of *O. papagorum* was located, was a narrow alluvial flood plain, which was matted with a variety of sedges and grasses. In the midst of this tangle of vegetation *O. annulatus* excavated a nest.

My attention was first attracted to this nest on the afternoon of July 4, about five o'clock. The wasp had evidently not been at work long, for the tube she was building was only about one-third of an inch high. I watched her for nearly an hour. During that time she made fifty-one trips into the burrow to remove earth. Ordinarily one of these trips was made in thirty seconds, though occasionally more time was required; two required over a minute each. She also made ten trips for water. She did not fly directly to the creek for water, as did all the others of this species that I observed, but went downstream to a sand bar. In most of these instances she would return to the nest in forty seconds, but would not always alight. She seemed greatly disturbed by my presence, although I would always lie prostrate on the grass when she went for water. Several times on her return from the creek she would fly away again without alighting, and would return several minutes later, hoping, no doubt, that I would be gone. One time she was gone eight minutes. She was also bothered by the wind, which had nearly stopped the activities of the colony of *O. papagorum* earlier in the afternoon. She would always alight on the grass above the entrance of her burrow, and seemed to do so with considerable difficulty. Before alighting she would always make a number of horizontal ellipses in the air above her nesting site. Perhaps these flights above the nesting site were to locate the exact position of the burrow.

This wasp worked much as did *O. arvensis*. She always backed out of her burrow with the pellet of earth, and applied it to the chimney with her mandibles and fore feet. Shortly before I left she began dropping pellets in a pile about three inches from the nest.

The next afternoon I returned to watch this wasp. She left the nest soon after I arrived, and returned in one hour and twenty minutes with a caterpillar. She spent five

minutes in the nest, and in fifty-seven minutes she brought another caterpillar. Like others of this genus, she carried it head foremost, ventral side up, grasping it with her mandibles and one pair of legs. She entered the tube dragging the caterpillar under her body.

The next afternoon I found her digging again. I took her for identification and opened the nest. The height of the tube was a little over one-half inch and its diameter was one-fourth inch. The tube was but slightly bent. Its walls were three-sixteenths of an inch thick, and their exterior surface was coarsely granular, like that of *O. arvensis*.

The burrow was nearly perpendicular. Including the cells, its depth was three inches. There were three cells, two in one gallery, which were stored and sealed up, and a single cell which was being excavated at the time I took the wasp. The cells were nearly globular and were one-half inch in diameter. Those that were stored were closed with thin mud caps. The walls of the burrow and the cells were packed, but did not form a layer of earth distinct from that surrounding them.

The two closed cells were stored with caterpillars, four and six respectively. Neither cell was packed. The caterpillar used was a naked green noctuid with three rows of dots on its sides. It averaged 15 mm. in length. I did not find the egg.

The third wasp of this species whose nesting activities I observed worked in the hard clay talus on a cliff, by the Saline river. She was an unusually large wasp for this species. The nest was first found by Mr. Williams, July 24. He marked the place and showed it to me that afternoon.

The burrow opened under a small flat stone—rather a flat pebble—which formed a protective ledge. From the entrance of the burrow, under the stone, the wasp built a horizontal tube similar in texture to the tube of the nest previously described. It was about one-third of an inch long. The clay in which the nest was excavated was very hard, so that I could scarcely dig in it with my digging knife.

The wasp was carrying out pellets when I first saw her. She would back out of the burrow, fly four or five feet and drop the pellet, and then return directly to work. Each excavation of a pellet required from two minutes and ten seconds to two minutes and thirty seconds. After every third

trip, usually—sometimes after every fourth—she would go for water. This required twelve to fifteen seconds. She would fly directly to the river below and alight on the agitated water. Sometimes she remained on the water for as short a period as six seconds. She continued to work in this way for an hour and forty minutes, and then flew away. In twenty-five minutes she returned to work, and was still there when I left.

At different times during the afternoon the wasp had manifested marked uneasiness because of my presence. If I crawled within eight or ten feet of the burrow she would invariably see me when she same out to drop a pellet, and then she would not continue work until I had withdrawn several feet. She never offered to fly away, as did the wasp previously mentioned. She showed her uneasiness by keeping up a zigzag flight about the nesting site, usually between me and the burrow. As soon as I would retire she would return to work.

The next afernoon I found her digging again. I caught her for identification and opened the nest. Opening the nest was a tedious task. Careful digging was very slow. I had expected to find a nest about three inches deep and with not more than four cells. In spite of that hard clay, this nest was seven and one-half inches deep and had twenty-two cells! What industry! What a Herculean labor for a wasp! And her work had not been finished.

The cells were arranged in five main galleries; some of these had small branches. The galleries diverged obliquely in different directions from the burrow, outlining a sort of a cone in the talus. The first division of the burrow into galleries was three inches below the entrance. The diameter of the burrow was one-fourth inch.

The cells were like ellipsoids. The diensions of an average cell were nine-sixteenths by seven-sixteenths of an inch. The largest number of cells in a single gallery was six. The walls of the cells and of the burrow were very smooth, almost forming a layer of earth distinct from the surrounding talus.

The nest had been in the course of construction so long that a part of the brood had already emerged. Eight cells contained only pupal exuviæ. Nine cells contained pupæ in various stages of development, one of which emerged the next day in a glass vial. Four cells contained grubs, three of which were evidently mature. In one cell with the other grub were

parts of two greenish caterpillars. Judging from the length of time it took others of this genus to develop, it had probably been stored not more than a week or ten days previously. There were no freshly stored cells. One cell contained twelve cast-off pupal cases of some small dipteron. This is the only indication that I found of interference with the activities of this wasp by another insect.

The larvæ and pupæ of *O. annulatus* were like the larvæ and pupæ of *O. papagorum,* only larger. The mature larva was 15 mm. long and very stout, being 7 mm. in width at the widest part. The pupæ were about 13 mm. long.

The capturing and subduing of the caterpillar prey by this species I observed but twice. In both instances the caterpillar was *Loxostege sticticalis.* The first caterpillar was taken on Russian thistle and the second on alfalfa. These observations were made in Trego county on July 12 and 13.

In the first instance the wasp spent five minutes dislodging the caterpillar from its nest. At last she seized the caterpillar by its anal end and deliberately dragged it backward over the thistle stem for several inches, until they both fell to the ground. The wasp then quickly grasped the caterpillar's neck, stung it three times under the thorax, and began maxalation. This process continued for four and one-half minutes. The wasp often rested, cleaning its abdomen and antennæ with its legs. When she started to fly I caught her.

In the other instance the wasp worked much more rapidly. She tore open the caterpillar's web, grasped it by the anal end, and they both dropped to the ground. The wasp quickly seized the caterpillar's neck and stung it three times under the thorax. She then maxalated the caterpillar and started to drag it away. After she had dragged it about five yards she took wing, circled high in the air, and disappeared. The entire process had taken two minutes.

O. annulatus was common hunting on the Russian thistle and alfalfa in Trego county.

Odynerus dorsalis Fabricus.

This large brown wasp was common in eleven of the twelve counties covered by the survey, being collected regularly between June 26 and September 6. I have collected this wasp as late as September 25 in Douglas county, on the State University campus. Like *O. arvensis,* it was most readily found in lowland pastures or by streams.

O. dorsalis, as I found her, was a burrowing wasp. I did not know that she ever built cells above ground until I read Mr. Hartman's paper. Usually she preferred to make her home in an open spot in a lowland pasture, in a path or in a well-traveled road. These nests were never found in sod, although sometimes a few blades of grass might be found in the space in which the nest was located. Even the vegetation around the space was always short, except in one instance. This exceptional nest I found in a stony knoll. The small space in which the nest was located was surrounded by a tall growth of mesquite grass (*Bouteloua oligostachya*). The soil in which the nests were excavated was always firm. The nest was always a vertical or nearly vertical burrow, at the bottom of which were one or two cells. No tube was built over the entrance. This situation was the usual one.

A variation from this form of burrow I found in the face of a vertical earthen bank of the Saline river. I found there a colony of eight nests, whose burrows led obliquely or horizontally for one or two inches into the bank, and then downward. The number of cells to each nest varied from three to seven.

The two types of excavated nests present a contrast to the earthen cells of the Texan *dorsalis,* built under a tuft of grass, which are described by Mr. Hartman.

The nesting season of *O. dorsalis* was at its height in the month of August. A wasp carrying a caterpillar was brought to me, July 24, by Mr. Williams. This was the earliest indication of nesting activities that came to my notice. In Osborne county, on August 4 and 5, the excavating and storing of seven nests were observed. At our next camp, in Rooks county, from August 6 to 13, four nests came under my observation. In Graham county, from August 13 to 20, I counted thirty-six nests either being built or stored. I might have found many more, but they were so common I did not hunt for them. In Norton county, from August 20 to 27, I believe they were no less numerous, but I took no count. There was a decided decrease in this line of activity in the next county, Phillips, where we were from August 27 to September 2. I found but two nests there. None was found after that.

The dates including the period of nesting activities of *O. dorsalis* may indicate the nesting period of only one generation. The colony located July 29, in the bank of the Saline

river, was mature. When I found it some of the wasps were emerging from their larval cells. I had no way of telling whether these nests were excavated earlier in the year, or whether they had been built the year before and the emerging wasps had wintered there. Throughout the month of July I had found *O. dorsalis* quite common about the watering places, but found no sign of nest building.

The nests of *O. dorsalis* found along roads or in open spaces in pastures, were, as I have stated, burrows, vertical or nearly so, at the bottom of which the larval cells were located, one above the other. The depth of the burrow to the bottom of the cells was sometimes four inches; the depth above the highest cell varied from three-fourths of an inch to two inches. The diameter of the burrow was one-fourth inch.

In three-fourths of the nests that I opened were two cells; the remainder of the nests had only one cell. The cells were always one below the other in the direct line of the burrow, never at one side.

In form the cell varied from globular to barrel-shaped. In size there was also considerable variation. Cells excavated in the same locality, in the same kind of soil and under the same conditions showed noticeable variations both in shape and size. Sometimes cells in the same nest differed markedly from each other. The extent of this variation may be shown by a comparison of measurements of cells of four nests located in open spaces in a pasture within seventy-five feet of each other. The descriptions of these cells as given in my notes are as follows:

Nest 1.—Two cells; globular. Cell 1—vertical diameter, 10/16 in.; horizontal diameter, same. Cell 2—vertical diameter, 11/16 in.; horizontal diameter, 10/16 in.

Nest 2.—One cell; globular. Vertical diameter, 10/16 in.; horizontal diameter, 11/16 in.

Nest 3.—Two cells, barrel-shaped. Cell 1—vertical diameter, 14/16 in.; horizontal diameter, 1/2 in.

Nest 4.—One cell; barrel-shaped. Vertical diameter, 3/4 in.; horizontal diameter, 1/2 in.

No tube was built over the entrance of this burrow, as is the case with so many of this genus, but the earth excavated was not left about the nest. The pellets are dropped in piles from eighteen inches to two feet from the entrance.

When the nest was stored with caterpillars, *O. dorsalis* did not stuff the burrow with earth. She simply closed the cell,

and then sealed the entrance to the burrow, always leaving a long vacant space in the burrow above the upper cell. The thickness of this mud plug which she puts in the entrance of the burrow I have found to vary from one-eighth to seven-sixteenths of an inch. The plug with which the cells were closed varied in thickness from one-eighth to five-sixteenths of an inch.

The locality of the nest, after it was closed, was often betrayed by a small basin-like depression, of which the closed entrance to the burrow was the center. The depression varies from one-half to three-fourths of an inch in diameter. It was caused by the removal of earth from the edges of the burrow entrance, to be used in sealing the burrow.

The nests whose entrances opened in the face of the earthen bank were similar to those already described, in that the cells were arranged one above the other as a series of enlargements of the burrow at its lower end. The cells were nearly all vertical, as was most of the burrow above the cells, although it entered the bank horizontally.

The number of cells to each nest was a marked difference between the nests of this colony and those previously described. The eight nests had a total of thirty-seven cells; the smallest number of cells in one nest was three; the largest number, seven. With one exception, the cells were arranged in a single gallery. The cells of the one nest which did not conform were in two galleries of four and three cells each, one excavated directly behind the other.

The cells in this colony were quite nearly alike in shape and size. All resembled barrels with rounded ends. The average height was fifteen-sixteenths of an inch; the average diameter one-half inch. The burrow before it reached the cells was from one to three inches long. Its diameter averaged nine-thirty-seconds of an inch. The depth depended upon the number of cells in the nest. In one in which there were six cells the base was eight inches below the entrance. The entrances to the burrows and the cells were sealed with mud plugs varying from one-eighth to one-fourth inch in thickness.

Let us now observe the building of a nest. A female *dorsalis*, running nervously over an open space about the size of my hand, in an Osborne county bottom-land pasture, attracted my attention. She would stop for an instant, and with her fore feet would sweep dust rapidly under her body. Then she

would run back and forth again, stopping occasionally in different parts of the open space to repeat the sweeping. This lasted for about five minutes, when, after concentrating her sweeping on an area of about one square inch, clearing it of loose earth and blades of grass, she took wing, made a circling, zigzag flight over the scene of her activities, and flew away in the direction of the river.

I remembered that *O. papagorum* and *O. arvensis* had behaved similarly before beginning work on a nest, so I sat down on the grass as near the open space as I dared and awaited developments.

In forty seconds she returned, wet a spot in the little area she had cleared, and began to dig with her mandibles and fore feet, gathering the earth into a pellet, which she held in her mandibles. After digging thirty seconds she arose and dropped the pellet about eighteen inches from the hole. All the other pellets she excavated were dropped about the same place. Trips for water followed regularly after removing every five or six pellets of earth.

To ascertain how much time was spent in carrying water, how much in extracting each pellet of earth, and how much variation there was in the time spent on each part of the work, I timed this wasp's trips. I kept the time record in detail in my notes, showing the number of seconds used for each trip for water and for removing each pellet of earth. I shall here give the first part of this record from my notes. All numbers, represent seconds. It follows:

For water, 40; for removing pellet, 30, 15, 25, 20, 20.
For water, 40; for removing pellet, 30, 25, 15, 25, 20, 20.
For water, 30; for removing pellet, 15, 20, 20, 15, 30, 40.
For water, 25; for removing pellet, 10, 30, 25, 35, 15.
For water, 35; for removing pellet, 30, 30, 30, 15, 20, etc.

Madam *Dorsalis* worked very steadily, never pausing while in the vicinity of the burrow. She would take wing the instant she backed out of the burrrow, and on dropping the pellet would fly directly back to it.

She worked steadily from 10:35 A. M. until 11:15 A. M. During those forty minutes she had removed eighty-six pellets and made sixteen trips for water. Most of the time she had been completely hidden while digging. When she returned from her seventeenth trip for water she flew to the burrow and started to enter, but when half way in she stopped sud-

denly and backed out. For a minute or two she seemed undecided. Several times she put her head into the burrow but did not enter. Then she located a new nesting site, two and one-half inches from the first one, clearing the ground by sweeping with her front feet, as before. At 11:19 she brought her first load of water and began work on her second burrow.

The depth of the deserted burrow, which this wasp had dug in forty minutes, the result of a total of 102 trips for water and for removing earth, was one and three-fourths inches. I could find no cause for the desertion of this nest.

O. dorsalis worked on the second burrow as industriously as she had on the first, and much in the same manner. At 1:05 P. M. she stopped digging and flew away over the pasture in search of caterpillars, storing six in one hour and five minutes. After depositing the sixth caterpillar she came out of the burrow, then backed into it, staying inside about three minutes—I supposed to oviposit. Then she flew away toward the river, and on returning entered the burrow. Later, when I opened the nest, I found that she had used earth from the sides of the burrow to furnish material with which to seal the entrance to the cell.

Sealing the mouth of the burrow was the next work. Earth at the edges of the burrow's entrance was moistened, then removed and applied to the sides of the burrow's entrance. When enough earth had been removed to completely close the burrow a basin-like depression was left. The process of sealing the entrance to the burrow occupied nine minutes. Two trips for water were made, each occupying thirty seconds.

This wasp had completed the entire work of excavating her nest, storing and closing it in three hours and five minutes. The burrow, which was two and one-eighth inches deep, was excavated in one hour and forty-five minutes.

One of the wasps I observed dug somewhat faster than the one just described. In one hour and twenty-five minutes she excavated a burrow with one cell, three inches deep, in contrast to one hour and forty-five minutes required to excavate a burrow two and one-eighth inches deep. For eight and one-half minutes I timed her trips. During that time she went for water four times and removed twenty-two pellets. The trips for water required about the same time as those of the first wasp, but the removal of a pellet of earth required only seventeen seconds on the average, while with the first wasp this

average was twenty-two seconds. The two wasps worked under the same conditions, as far as that is possible. Both nests were in the same open space, being within three inches of each other. They also had the same advantages of temperature, for I was watching both nests at the same time. The second wasp began working ten minutes after the first one had begun her second nest. Although the second wasp worked more rapidly in digging, it took her twice as long to store six caterpillars in her nest.

Two other nests, whose progress I had kept note of from their commencement until their completion, required a much longer time for this process. One was closed twenty-one hours after it had been begun; the other was closed twenty-five hours after its commencement. Both were nests with two cells.

Two hesperid caterpillars were preyed upon by *O. dorsalis*. The larvæ of the spotted skipper (*Pyrgus tesselata*) was taken by *O. dorsalis* exclusively in Russell and Osborne counties; the larvæ of the black skipper (*Philosara catullus*) was the only caterpillar that I found in its burrows. The first caterpillar was common on the poppy mellow (*Callirhœ involucrata*), an abundant and conspicuous plant in many lowland pastures. I always found the larvæ in a nest made of a crumpled leaf or two, whose edges were held together by a silken web. Sometimes this web was in the heart of the plant. The black skipper larva Mr. Williams collected on the pigweed (*Amayranthus retroflexus*).

One afternoon of the first week in August, at about 3:20 o'clock, I stationed myself before a burrow to watch particularly the storing of prey. In fifteen minutes the wasp visited the burrow, but brought nothing. She left the nest quickly, and in two and one-half minutes returned with a caterpillar. Two minutes were required in storing it. She brought another caterpillar in fifteen minutes, again staying in the nest three minutes. The next caterpillar was brought in two and one-half minutes. She then spent twelve minutes in the field, and returned with nothing. She brought a fourth caterpillar in fifteen minutes and stored it in three minutes more.

Evidently the cell was full, for when she came out Mrs. Wasp flew in the direction of the river and returned in a minute with her mouth parts glistening. She stayed in the burrow two minutes, presumably to close the cell. Then she

came out and quickly backed into the nest. Probably she backed in to oviposit in the empty upper cell. She stayed in two minutes, and then went to the field again. In two minutes she had brought a caterpillar. Here I left her for the day.

The next morning soon after 7 o'clock I was waiting at the door of the burrow. At 7:35 her head appeared in the doorway. Evidently she had backed into her burrow and spent the night there. She waited there until 7:48, and then took wing. Her morning's hunt was entirely unsuccessful as far as I observed it. Perhaps the comparative coolness of the morning affected her. She made six successive trips to the field and returned each time without prey. The time required for these trips, respectively, was as follows: 16, 12, 21, 15, 12 and 15 minutes. The purpose of her return seemed to be to inspect the nest. After her second trip to the field it appeared that she was about to begin further excavations in her burrow. She carried out three pellets, the removal of each one requiring about a minute. She then returned to the hunt.

After her sixth "empty-handed" return to her nest I followed the wasp to the field, to learn, if possible, the cause of her lack of success. She seemed to be in earnest about hunting. She would fly from one mallow plant to another, running over the leaves and stems. Twice she found a caterpillar and struggled with its web, but did not seem able to dislodge the inmate. In one of these instances she worked four minutes trying to tear open a caterpillar's nest before she gave it up. Another time she was successful in dislodging a caterpillar, stung it twice, and then dropped it. She then continued hunting on the same plant, and once actually walked over the prostrate caterpillar, but did not appear to notice it. After following her for twelve minutes I left her. I returned to the nest an hour and a half later and found her closing it. She at once located a new nesting site within a few inches of the first one and began excavations for another nest. By noon and throughout the afternoon she was again carrying caterpillars as busily as she had been the day before. Both nests were two-celled.

O. dorsalis was easy to follow while hunting in a mallow patch. The plants were small and spreading and could not hide her movements. Her flights from plant to plant were short, and she spent considerable time running over each plant. She seldom seemed sensitive to observation, and her large size

made her conspicuous. The situation in Osborne county was made still easier for study because the nests of *O. dorsalis* were located in a pasture overgrown with the poppy mallow. This often made it possible for me to follow a wasp from the nest to the field, and after having observed the capture of a caterpillar to run back to the nest before she had pushed the caterpillar in.

When *O. dorsalis* would come upon a crumpled leaf containing the larva of the spotted skipper, she would commence tearing energetically at the silken nest, first at one end, then at the other. Although the wasp worked furiously and without pausing, sometimes more than five minutes were required to dislodge the caterpillar. Usually, however, in less than a minute the caterpillar would be jerked violently from its cover, seized by the neck, and stung two or three times under the thorax. Once I saw a wasp seize a caterpillar by the tip of the abdomen to jerk it out of its nest, and sting it under one of the last abdominal segments. Then she quickly seized its neck and gave it three thrusts under the thorax. A vigorous maxalation invariably followed the stinging. The capture of a caterpillar generally occasioned considerable excitement on the part of the wasp. Sometimes she would lose her footing, and both insects would roll from the leaf to the ground before the victim could be subdued.

After maxalation, without further delay the caterpillar is carried to the nest. *O. dorsalis* always carried the caterpillar in the same manner as did all the others of the genus that I have observed. The caterpillar, head foremost and ventral side up, is grasped by the wasp's mandibles and one pair of legs. The wasp always flew directly to the burrow. Her flight was usually quite slow, for the caterpillar seemed to be a heavy burden. On alighting the caterpillar was pushed ahead of her into the burrow, and the wasp, seizing its last abdominal segment, followed it in. *O. dorsalis* was always in a hurry.

The number of caterpillars in a cell, with the exception of three cells, varied from five to seven. In Graham county, August 19, I opened a nest with two cells containing three and two caterpillars, respectively. A week later, in Norton county, I opened a two-celled nest, containing five and two in each cell, respectively. The caterpillars were all about the same size. They were stored in a more or less tangled mass. In many

instances the cell was packed; sometimes I would find a fair-sized space above the caterpillars.

All of the caterpillars that I took from nests of *O. dorsalis* showed signs of life. The abdominal segments invariably responded to stimulation. However, I found none as active as some stored by *O. papagorum* and *O. arvensis*.

The egg was usually suspended from the ceiling of the cell by a white thread, sometimes as long as the egg itself. In an exceptional case the egg was on a caterpillar, being attached by a thread to its seventh abdominal segment. This caterpillar was on the bottom of the cell and was probably the first one stored.

Although attached to the ceiling, the egg is not always suspended above the caterpillars. It was only in exceptional cases—in unusually large cells—that I found it so. I have found it hanging among the caterpillars. Usually I could not find the egg at all until some of the caterpillars had been removed.

The time of oviposition, in relation to the storing of the nest, probably varies. On one occasion I noted a wasp back into its cell after it had been stored, supposedly for oviposition, and just before it had been sealed up. I concluded then that oviposition takes place after the storing of the caterpillars. My conclusion was upset when I saw a wasp back into a new cell in which nothing had yet been stored. Several times I found eggs suspended in cells only partially stored, and twice in cells that were entirely empty. I also opened a number of empty cells in which I found no egg.

The egg of *O. dorsalis* is ellipsoidal and rounded at the ends. Its length is about 4.5 mm. and its greatest diameter is 1.5 mm. It was more nearly flattened at the end of attachment to the thread. It was also less rounded on one side than on another. Its shape reminded me of that of a cucumber. In color the egg was creamy white. The thread attachment was white and about the same length as the egg.

But one *O. dorsalis* grub came under my observation. Mr. Williams saw a wasp closing its nest on the afternoon of August 7. He marked the place and showed it to me. Five days later I opened the nest. It had one cell containing seven caterpillars and a grub, which I should judge was about one-third grown. In appearance this grub was like those of other

species of this genus, very stout, being larger near the anal end, and whitish in color.

The last of the pupal stage I had opportunity to observe in the bank colony of nests. Two pupæ, almost ready to disclose wasps, were taken from the lower two cells in a gallery of four. In another nest in the lowest cell another pupa was taken. The rest of the nests were empty. I placed these pupæ in glass vials. One disclosed the next day and the other two disclosed on the third day after I had taken them. All were females. These pupæ were colored almost like the adults, except that the rufous on the abdomen was lighter, and the yellow ornaments were pallid. All were resting on the tips of their abdomens, with their heads upward.

My attention was attracted to the location of the bank colony by a number of males of *O. dorsalis* which collected on the face of the bank around openings to these nests from which wasps had emerged. Occasionally one of the males would inspect the entrance of all the open burrows in the bank. At two of the burrows these males always stopped to put in their heads, and sometimes one would enter part way. While he would fly to the others in the course of his circuit, Mr. Wasp would stop at them only momentarily, and then take wing again. The two burrows in which the males manifested such a special interest proved to be the ones which contained the female pupæ nearly ready to be disclosed.

These males were very quarrelsome. Often when one would put his head into the burrow another would dash at it, and together they would fall to the base of the cliff. Occasionally they would dash at each other without any evident provocation.

From the fact that only females were found in the lower cells of these nests, and that males were waiting apparently for their emergence at the mouths of the burrows, I should judge that males emerge first, as in the case of others of this genus. Perhaps the upper cells of the galleries, which were empty, had contained these males.

In a number of the empty cells of this colony I found heads of caterpillars, probably hesperids, evidently discarded by the wasp grub.

O. dorsalis had an abundance of insect enemies. The findings in the cells of the bank colony may suggest the extent to which other insects interfere with their increase of numbers.

Of thirty-seven cells opened at least eighteen did not produce *O. dorsalis*. In one of these eighteen cells I found the pupa of a bombyliid, probably of the genus *Anthrax*. In one of these cells was an empty pupal case, probably of a chrysidid. In the walls of two other cells I found tachinid flies. These flies had endeavored to break their way out of the cells by burrowing into the wall, and had perished. In the remaining fourteen cells were found many dipterous pupal cases, perhaps also tachinid. These flies may have been parasitic upon the caterpillars stored, but at any rate they prevented the development of the wasps.

I opened a two-celled nest in Rooks county in the upper cell of which were seven recently stored caterpillars; in the lower cell were only caterpillar skins and many almost minute springtails. I once took a mutillid (*Mutilla simillima*) in a nest. The cuckoo bee (*Chrysis intrica*) was so closely related to the nesting activities of *O. dorsalis* that I shall deal with it separately. I have taken a large robber fly (*Deromya* sp.) carrying this wasp.

Chrysis intrica always attended the excavation and storing of the nests of *O. dorsalis*. I never watched the domestic activities of this wasp but that a cuckoo bee was present. The *Odynerus* could scarcely begin digging before one of these ubiquitous parasites would appear. *Chrysis* would wait patiently, facing the nest, on the tip of a grass blade a few inches away. It manifested its interest in the proceedings by darting into the burrow occasionally, and then hurriedly resuming its position on the grass blade. Sometimes it would even enter the burrow when the wasp was within. Often there would be two or three cuckoo bees waiting around one burrow.

Ordinarily the wasp and the cuckoo bee seemed to pay little attention to each other. The cuckoo bee was nearly always motionless in the wasp's presence. When the wasp did dash at the cuckoo bee it would take wing or drop into the grass. The wasp was never successful in catching it. When the wasp would go back to work the cuckoo bee would resume its position. Three times I saw *O. dorsalis* carry *Chrysis* out of her nest with her mandibles; but each time she dropped the parasite like a pellet of earth, and left it apparently unharmed.

On one occasion Mr. Williams and I watched *Chrysis* break into a nest of *O. dorsalis* after it had been sealed up. The wasp had closed its burrow entirely and had gone for water with

which to melt some mud for the finishing touches. Suddenly the cuckoo bee, that had been passively waiting for some time, seemed to realize that she was about to be shut out. She flew to the nest, and with little difficulty made an opening in the cap, and disappeared just before the owner of the nest returned. Upon alighting the wasp paused a moment. She saw instantly that something was wrong. She then tore out entirely the cap she had so carefully made, and rushed into the burrow. She soon reappeared with the intruder in her mandibles, and dropped her on a pile of pellets. She then went for another load of water and again sealed up the burrow. *Chrysis* took her position on the grass blade and watched the proceedings, but did not again interfere.

O. dorsalis had a tendency to nest in colonies. I sometimes found an isolated nest, but usually the nests were in small groups, sometimes as many as eight. Usually only two or three wasps would share an open space in a pasture, each wasp digging one or two nests. I never found them in populous colonies like those of *O. papagorum.*

These wasps sometimes manifested considerable curiosity in each other's work. This characteristic I first noticed in two wasps digging in an open space within three inches of each other. When one was gone for water the other would sometimes leave its work and inspect the work of the absent party by putting its head into the entrance. However, I never saw a visitor presuming to enter. The visitor would always hastily return to its own burrow at the near approach of the owner of the inspected burrow. I never saw the females of this species quarrel.

O. dorsalis was always most active during the heat of the day. On bright sunny days during the nesting season the wasp was apparently busy from eight o'clock in the morning until near sundown.

O. dorsalis seemed to be the most cautious of all the members of this genus about floating upon water. Some individuals would float upon pools, but never upon running water. On a gravel bar on the Solomon river I watched one of these wasps come for water. She would alight about six inches from the water's edge and would walk out to it. When on water, or at work elsewhere, *O. dorsalis* always kept its wings spread and raised at an oblique angle from the thorax, ready to take flight at any instant.

I sometimes collected males of this species on sand or gravel bars by streams, where they were apparently sunning themselves. They were never abundant there, however, as was *O. arvensis.*

O. dorsalis never seemed to have any difficulty in finding her way to her burrow after a trip to the field. Usually she flew directly to it; I never saw her do otherwise when she was returning from the field with prey. At times when she returned from the field unladen, I have seen her pause at another burrow in the colony. This action may have been prompted by curiosity instead of being a mistake in location. I have noted a number of these wasps make a locality study above a spot selected for a nesting site.

Although not generally sensitive to observation, *O. dorsalis* was more responsive to changes in the surroundings of her burrow than was *O. papagorum.* A few marks with a knife, to assist in locating a nest at a later time, seemed to disturb one wasp considerably. On her return to the nest she made a prolonged observation flight of irregular circles above her nest, while she had been in the habit of alighting without any hesitation. On another occasion I mutilated slightly the entrance to a burrow. Upon the wasp's return she circled around the burrow a few times and then alighted about two inches from the entrance. She flew away and returned in about a minute and repeated the observation performance. Again she flew away and returned without entering. This time she apparently deserted the nest.

Pterochilus 5-faciatus Say.

In the middle of a sandy road, beside the Saline river, Mr. Williams and Mr. Mallory noticed a large eumenid dragging a long caterpillar under her body. I was only a short distance away, and they called me to see it. The eumenid entered a thicket of *Chenepodium,* dragged the caterpillar to a large hole about two feet from the roadside, and entered it quickly, still dragging the caterpillar under her body.

We left *Pterochilus 5-faciatus* there—for she was so identified later—and continued on our way to locate and pitch a temporary camp. This observation was made at 12:30 P. M., July 24.

I returned to the nesting site at 3:40 P. M., and *Pterochilus* appeared twenty-five minutes later. She brought nothing, but

alighted in the middle of the road, ran into the weeds to her burrow and entered. A minute later she came out, not backwards as do the members of the genus *Odynerus*, but head foremost. She always came out in this manner. She walked deliberately to the open road before she took flight. Again in twelve minutes she came, unburdened as before, and repeated her visit to the nest, staying a minute. In fifteen minutes she returned with a caterpillar. In my eagerness to observe every movement I moved forward slightly and she seemed to notice me. She poised a moment, then flew high in the air and out of sight. She returned in fifteen minutes, but without prey. This time she stayed about three minutes. She again flew away and had not returned by six o'clock, when I left for camp.

Madam *Pterochilus* was filling her nest with sand when I returned the next morning at 8:30 o'clock. With her front feet she would vigorously scrape together a heap of loose sand near her burrow, and then push it with her front feet into the entrance. After pushing in several heaps she would go down, no doubt to press it in place more firmly. In less than five minutes the burrow was practically filled. I took her then for identification. No water had been used in closing the burrow.

I then opened the nest. It was excavated in very sandy soil. The burrow led to two horizontal galleries, one of which terminated in a single cell and the other in three. The main burrow was two and three-fourths inches deep and seven-sixteenths of an inch in diameter—almost twice the diameter of the burrow of *O. dorsalis*, a wasp of nearly the same size. The direction of the burrow was obliquely downward, with but one break in its course. None of the cells were in the direct line of the main burrow, nor did any of them open directly into the burrow. At its bottom the burrow branched abruptly into two horizontal burrows leading in opposite directions. One side burrow was only one inch long before it reached the single cell. The other side burrow was two and one-fourth inches long before it reached the first cell of the gallery. When packed with sand the burrows were quite hard to follow.

The cells were shaped like short casks, lying on their sides. In the gallery with three cells they were arranged one behind the other. The cells averaged three-fourths of an inch in length by ten-sixteenths of an inch in diameter. The partitions between them were of sand, and were from one-sixteenth to

one-eighth of an inch in thickness. The particles of sand in the partitions seemed to adhere much better than the sand in the tube. This led me to think that some fluid had been added to it.

All of the cells were supplied with caterpillars. In one cell two were stored; in another were four, and in each of the others were three. The caterpillar was a rather stout, naked noctuid. In color it was light green; it had two rows of black dots on each side and many white lines on its back and sides. It was from 23 mm. to 25 mm. long.

Two eggs were found. They were suspended from the ceiling of the cells at the end farthest from the entrance. The eggs were shaped like those of *Odynerus*. They were 3.75 mm. long by 1.2 mm. in diameter. The threads by which they were suspended were about the same length as the eggs.

This wasp's manner of return to her nest was noteworthy. She would always alight in the middle of the sand, and then go directly through the weeds to her burrow. She did not always fly directly to the road, however, on her return trips. On several occasions she circled over the *Chenipodium* patch before alighting. Perhaps she was disturbed by my presence. When leaving the nest she always went into the open before taking wing. On coming to the nest she would always appear high in the air, and on leaving she would always rise high at the start. This high flight may have been because her hunting ground was a long distance from her nest.

Another burrow of *Pterochilus 5-faciatus* I found in a sandy bank by the Smoky Hill river. While walking along the edge of the stream I saw a large wasp dash from a burrow. Thinking she was a bembecid, I swept at her with my net and quickly put her in my killing bottle, and so spoiled the opportunity for observation.

When I saw that I had taken a eumenid I opened the burrow. I found just a straight burrow three inches deep leading obliquely into the sand. This burrow was located in a barren bank of loose sand about four feet above the river and not ten feet from its edge. The observation was made July 12.

Odynerus hildagi Saussure.

While watching the nest-building of *O. papagorum* in cliffs in Ness county, my attention was attracted to a medium-sized *Odynerus* also entering a burrow in the face of the cliff. Later

investigations proved this wasp to be *O. hildagi*. The following observations were made on the afternoon of July 6 after 4:30 o'clock.

This mother wasp was busy storing her nest with caterpillars when I observed her. She used the same caterpillar that was the prey of *O. papagorum*. It was very small in proportion to the wasp and was handled with apparent ease.

The wasp always flew directly to the burrow, carrying the caterpillar, ventral side up, under her body. She grasped the caterpillar by the neck with her mandibles, and also held it about the abdomen with her middle pair of legs. When she reached the burrow she hastily thrust the caterpillar ahead of her, holding one of its last segments with her mandibles as she disappeared.

After she had stored eight caterpillars in my presence, Madam Wasp returned from her ninth trip with a pellet of mud, evidently from the creek. She worked inside the burrow five minutes, backed out, paused a moment at the entrance, and went in again. Again she came out and reëntered without taking wing. When she came out the next time she stood on the edge of the burrow and tried to back in, presumably to oviposit. But she failed to back in, for she thrust the tip of her abdomen against the side of the cliff instead of into the burrow.

Then followed the most ludicrous performance I had ever known a eumenid to be responsible for. Eleven times in succession this wasp stood with all six legs on the rim of the burrow entrance and tried to curve her abdomen under her, apparently to thrust it into the burrow. Instead of doing this, each time she thrust the tip of her abdomen against the cliff side at the burrow's edge. After each failure she would turn around and peer wonderingly into the burrow to see what the trouble might be. Sometimes she would go half way into the burrow. After each investigation she would again poise on the rim of the burrow and again try to back into it.

Her twelfth attempt was partially successful. She would have succeeded had she pushed the tips of her wings into the burrow as well as her abdomen; but one of them caught in the edge. She could back into the burrow only to the point of the wing's attachment on her thorax. Three minutes of struggling failed to free the wing or to bend it. She came out

and reëntered the burrow head first. Twice more she tried to enter the burrow and failed. Then in evident disgust she flew away.

In eight minutes she returned, entered the burrow, came out quickly, and again tried backing into it. Her third attempt was successful. This time both of her wings caught outside of the rim of the burrow, but by several minutes of pulling and twisting she bent them so that she could enter.

She stayed in the burrow four minutes, and then at once began storing more caterpillars. After her sixth trip I caught her for identification.

This wasp was the fastest worker of all the members of this genus that I had observed. The time she spent inside the burrow storing her caterpillar varied from five to eight seconds. She entered the burrow quickly and did not waste a moment, starting on the hunt as soon as she had backed out. Also she was the quickest to return to her nest with prey. Seven of the hunting trips which she made before trying to oviposit I timed as follows: 7, 6, 3, 4, 4, 6, and 7 minutes, respectively. After oviposition the time of the trips was as follows: 5, 1½, 3, 4, 8, and 7, respectively. This wasp could go to the field, bring in a caterpillar and store it in the average time required by *O. papagorum* for the storing process alone.

After taking the wasp I opened the nest. It contained four cells, three in one gallery, and one cell directly behind this gallery. As the burrow entered the cliff it pointed in horizontally and then curved downward. The cells were practically vertical, and were arranged one above the other.

The base of the lowest cell was about three inches below the entrance of the burrow. The burrow at the entrance was nearly one-fourth of an inch in diameter. The cells were ten-sixteenths of an inch long and six-sixteenths of an inch in their widest diameter.

These cells were built in the cliff; they were not simply excavated, but were distinct from the earth that surrounded them, so that when it was removed I was able to take out the cells and remove them to a box. When removed, these so closely resembled the much larger cells of *Anthrophora occidentalis* that I was led to believe that the wasp did not build this nest, but preëmpted a nest of one of the smaller digger

bees. The nest was lined with a kind of paper, and so was the burrow.

The upper of these cells contained the six caterpillars that I had seen stored, and an egg suspended from the roof of the cell, in a manner similar to that of the other eumenids that I observed. The next cell was packed with caterpillars, eighteen of them, but I did not find the egg. All the caterpillars that I investigated responded to stimulation.

The two remaining cells I left unopened and kept in a tin box. On September 14 a male wasp emerged from one of them, at least two months and eight days after the cell had been stored. Instead of breaking open the cap of the cell when he emerged, this wasp cut out a circular hole in the side of the cell. He was influenced in this, no doubt, because the cell lay on its side in the box instead of upright as it should have done naturally. The length of time spent by the wasp within the cell may also have been affected by the abnormal conditions.

O. hildagi is a rare wasp in western Kansas. But four specimens were taken during the summer's trip.

Odynerus sulphuritinctus Vierick.

A single female of this species was taken by Mr. Williams, coming out of an old mud dauber's nest, located under a ledge in the chalk cliffs on the Smoky Hill river in Trego county. It was the only specimen of this species taken during the summer. It was taken July 10.

Eumenes bolli Cresson.

On tall prairie grass and weeds in a ravine in a Ness county I found a favorite night resort for thread-waisted sphecids of the genus *Ammophila*. There, more or less protected from wind, they would collect in the evening to spend the night, grasping the grass stems with their mandibles and legs, holding their bodies rigidly away from the stems. A number of scoliids was also collected in this ravine, resting on horizontal branches of weeds and on grass blades. There also I found a solitary *Eumenes bolli*.

This wasp was hanging on a horizontal branch of *Dalea* sp. It did not hold its body rigid and in line with the stem as did the *Ammophila*, but held itself at right angles to the stem, with its long petiolate abdomen curled under it. With its legs it

held the branch above and with its mandibles it griped the leaf which was attached to the branch between its fore legs. This was taken July 6.

Two others of this species were taken the next week in Trego county. One was flying along the dry bed of an intermittent stream and the other was taken on the leaves of a solitary cottonwood tree. This species was observed on two other occasions during the summer—once by Mr. Williams, on August 2, in Osborne county, flying over a prairie hillside. On the other occasion, August 26, in Norton county, I noted *Eumenes bolli* take water at a stock tank in an open pasture. She did not alight directly on the water, but on a sunflower leaf floating in the tank.

Three jug-shaped nests of *Eumenes* were found during the summer. The first was found by Mr. Williams on July 24, in Russell county. This nest was in a ravine, attached to a branch of *Onosmodium molle,* about eighteen inches above the ground. The nest had apparently been built and then deserted. A second nest I found on August 8, in Rooks county, in a ravine, attached to a branch of *Euphorbia marginata.* This nest had a circular opening in its top—not through the mouth of the jug—from which the wasp had evidently emerged. The next day I found a third nest, attached to a twig of *Rhus canadensis,* about two and one-half feet above the ground. This shrub was growing on the side of a sand dune. From this third nest a male *Eumenes bolli* emerged August 28. One of these nests was within 50 yards of water. The other two were each about 400 yards from water.

Nests of *Eumenes* have previously been described by others as jug-shaped cells. The cells of *E. bolli* were like shortened jugs, which, not considering the mouth, were nearly globular. The side which was attached to the more or less upright plant stem was somewhat flattened. The flaring mouth opened near the middle or above the middle of the side opposite the point of attachment. The diameter of the jug varied from one-half to nine-sixteenths of an inch. The entrance in the mouth was three-sixteenths of an inch in diameter. On the exterior of the jug were small rounded ridges and some rounded prominences, showing how the layers of earth had been added by the potter. However, the surface was smooth, not granular. These nests are made of earth, but I have thought that some-

thing besides water—perhaps saliva—must be mixed with the earth to insure the permanence of the nests through various kinds of weather.

Eumenes fraternus Say.

A two-celled nest of *E. fraternus* was found by C. H. Withington on a dogwood branch, March 6, 1909. At the time the nest was taken it contained full-grown larvæ. Two female wasps emerged May 10, 1909. The nests and wasps, with an explanatory note, were placed in the Snow collections.

The cells of this nest were two earthen jugs attached to each other so that one lateral wall served for both. They were similar in shape and size to the nests of *E. bolli*, but were flattened beneath where they were attached to the horizontal branch of dogwood. While alike in general plan, these nests showed considerable variation in structure. One was higher, more covex above and more nearly round; the other was considerably larger. One nest was placed with its long axis at right angles to the direction of the branch; the other obliquely to it.

Eumenes sp.

A jug-shaped cell, somewhat like those of *O. bolli*, was brought to me by Will H. Collins, a student of entomology at Kansas University, October 21. This nest he had found attached to the upper surface of a flat stone, in a wood about three miles south of the University campus. The lower side of the cell, where it was in contact with the stone, was much flattened. Otherwise it was similar in appearance to the nest of *E. bolli*. Two reperesentatives of this genus have been taken in Douglas county—*E. fraternus* and *E. smithi*.

SUMMARY.

I shall now summarize some of the data that can readily be grouped.

Eumenidæ are friends of plant life. The adult insects are to a certain extent flower pollenizers. From Mr. Hartman's observations on *O. dorsalis* we learn that the adults sometimes also take animal food for themselves. The food of the wasp grubs, as far as is known, is exclusively plant-feeding larvæ of other insects. Some of these larvæ preyed upon are obscure species, making the work of wasps that prey upon them neutral so far as economic importance goes. There are many other

instances of eumenids destroying insects of considerable economic importance. Representatives of the following families are recorded as being destroyed by eumenids: Lepidoptera—Notuidæ, Pyralidæ, Hesperidæ, Tortricidæ, Geometridæ, and Œcophoridæ; Coleoptera—Curculionidæ and Scurabidæ; Hymenoptera—Tenthredinidæ.

The economic insects destroyed by eumenids that are noted in this paper are as follows: Cutworms, destroyed by *Monobia quadridens*, noted by Ashmead; canker-worms, noted by Harris and the parsnip web-worm (*Depressaria hearcliana*), noted by Southwick, both destroyed by *Eumenes fraternus;* the Larch sawfly (*Nematus erichsonii*), destroyed by *O. capra,* observed by Fyles; *Pempelia gleditschiella,* destroyed by a small *Odynerus,* observed by Marlatt; the cotton worm, destroyed by *O. dorsalis,* observed by Hartman; *Loxostege stricticalis,* destroyed by *O. annulatus,* observed by Hungerford and Williams; the same caterpillar, destroyed by O. *arvensis,* observed by myself.

A comparison of four species that I observed indicates that the tube which some species construct over the entrance of their burrows is of value in excluding parasites. The observations are too few to serve as anything more than an indication of this. *O. dorsalis,* which built no tube, was heavily parasitized, while *O. papagorum, O. arvensis,* and *O. annulatus,* all tube builders, seemed little troubled with parasites.

The most persistent parasites of the Eumenidæ are in the family Chrysididæ. Other families, representatives of which have been found in nests of eumenids, are: Diptera—Bombyliidæ and Tachinidæ; Hymenoptera—Ichneumanidæ, Braconidæ, Mutilidæ, and Myrmicidæ. Aptera—robber flies (Asilidæ)—may also be listed as enemies of the Eumenidæ, although they have not been taken in nests of eumenids.

The purpose of the suspension of the egg from the roof of the cell can not be, for all species, as Fabre suggests, to prevent the egg from coming in contact with the writhing larvæ. If this is the purpose of the suspensory thread, it is unsuccessful in many cases. In the observations of the Peckhams on the nests of *O. anormis,* and in my own observations on four species, *O. papagorum, O. dorsalis, O. annulatus* and *O. arvensis,* the egg was found among the caterpillars. Riley refers to Harris as stating that the nest of *E. fraternus* was packed

with caterpillars, which suggests that the egg could scarcely have been suspended above them. Mr. Hartman's experiment with the egg of *O. arvensis* showed that being among a number of very lively caterpillars did not injure the egg or the young wasp larvæ, at least in that instance.

The arrangement of caterpillars, as in the nest of *O. reniformis* which Fabre described, so that the wasp larvæ could eat caterpillars in the order in which they were stored, can scarcely apply to many species of *Odynerus*. In all of the nests that I observed the caterpillars were not stored so that the wasp larvæ would be able to select them in the order in which they were stored. With some wasps that stored their cells within one or two hours, the order of storing could have made little difference in the relative strength of the different caterpillars.

I collected some data on the observing ability of four eumenids. This evidence is not sufficient to base any conclusions upon, and a part of it is contradictory.

O. papagorum, O. arvensis and *O. dorsalis* all made locality studies before beginning work on a burrow. This one locality study before the beginning of work was the only one I ever observed any of these wasps make, if undisturbed. They always flew directly to the burrow, because, I had supposed, they had an accurate memory of their immediate surroundings. *O. annulatus* frequently made a short locality study before alighting at her burrow.

When I put sunflowers in the midst of a colony of *O. papagorum,* mutilated a number of nests in another colony, and disfigured the face of the cliff for several inches around the colony, none of the owners of nests seemed to be disturbed, and at first only one wasp seemed to even notice the change. They flew as directly to their nests as before. If these wasps had any observational ability at all, why were they not alarmed by the depredations about their nests? How did they know that those nests that they entered so confidently were their own? Could they have been guided by a sense of direction and not by memory of the surroundings of their nests?

O. dorsalis usually noticed a few marks about her nest, but only once did she seem to resent changes for any length of time. In this instance I had cut away a part of the entrance to her burrow, and she deserted it. The same was true of this

species as observed by Mr. Hartman. When he pulled up the grass before her nest she was disturbed only for the moment. Neither *O. papagorum* nor *O. dorsalis* objected to being observed.

O. annulatus was sensitive even to my presence in the vicinity of her nest, and sometimes delayed work because of it. None of these species were as extreme in sensitiveness as *O. vagus*, mentioned by the Peckhams, which delayed work for half an hour because of a red match head within two inches of her burrow.

It was interesting to me to note that *O. annulatus*, which seemed to be the most plastic in habits of all the species I observed, was also apparently the best observer. *O. papagorum*, whose habits seemed inflexible, at least in the choice of a nesting site, appeared to be a very poor observer.

A fact that greatly impressed me in my study, and that sometimes astonished me, was the variability in habits exhibited by members of this family. I had expected the different species of the family to differ from each other, but a wide variation was often exhibited by members of a species.

Within the species *O. annulatus* I found one lazy individual that used a vacated mud dauber's nest as her storehouse; another individual of the same species laboriously excavated a twenty-two-celled nest in the hardest of clay. The variation among individuals of *O. dorsalis* is not less striking. I was surprised when I found that this wasp dug its nest in two situations, as either in the side of a bank or in level ground. My surprise grew to astonishment when I read Mr. Hartman's account, stating that *O. dorsalis* also constructs cells above the ground. *O. arvensis*, too, varies widely in its choice of nesting sites; I found her to be a burrower in various situations, while Mr. Hartman credits her with building in convenient holes and crevices.

As far as I observed, *O. papagorum* is in many ways a dissenter from this rule of variation, at least in regard to nesting sites and the type of nest used. She appeared to have but one favored nesting site, and that was limited by a number of conditions. I believe her to be less plastic also in her other habits than the species mentioned. Yet within this most stable species variations were on every hand. For instance, consider the cells, their variability in number in a nest, in arrangement, and in the direction of their long axes. Or consider excep-

tions—the wasp that had not sufficiently subdued her caterpillar; the wasp that discarded the earth she excavated and stole fresh earth from the *Anthrophora* tube to build her own, or the wasp that struggled to carry earth into her nest, in spite of a windstorm that forced the other members of the colony to stop work. In many of the minor activities connected with the nest, the other species, as well as *O. papagorum,* showed a wide range of variability.

Yet these variations are not without a limit. There were in most cases certain habits, typical of a species—just as there are type specimens in structure and coloration for each species—about which the variations centered. As, for instance, while there might be a great difference between the shape of two cells of a species, representing the two extremes in variation; yet the majority of cells would be between the two extremes, and the difference between many of them could be known only by careful and minute measurements. Again, caterpillars in varying states of mobility were stored by individuals of a species; yet this difference in most instances can scarcely be known without a close comparison of individual caterpillars. I know of no mean between the two extreme types of nests of *O. dorsalis*—the burrow, and the cells above ground; perhaps when our knowledge of this species is more complete this mean will be found.

In spite of this variability in many habits, there were certain other habits that characterized the family—habits that seemed inflexible and that occurred in all the species observed. There were certain other fixed characteristics that belonged only to a species or to a genus. In the genus *Odynerus* the wasps do not turn around in the nest; if a wasp has gone into a nest head foremost it comes out backwards. All that I observed used water in nest-building. Members of this genus always take wing after taking out a pellet from a burrow, and drop the pellet while in the air. I have noted no variations from these habits.

I shall mention some of the habits of the family that are least flexible of those I noted. The food of the wasp grub was always a plant-feeding larva. With no exception, all of the lepidopterous larvæ whose environment I observed or that I have read of were spinners. Why such should be preferred I can not imagine. As far as I observed, the caterpillar was always carried in the same way—its head foremost and its

ventral side up. All the eumenids suspend their eggs by filaments from the cell wall. A single individual of *O. dorsalis* violated this rule, possibly accidentally, by attaching an egg to the caterpillar. When floating on water or at work elsewhere a eumenid's wings are always held open and at oblique angles to its thorax; it is always in position to take flight at any moment.

These habits were conspicuous among the activities of the wasps that I observed, because of their uniformity both among the species and the individuals. To me they have seemed to be invariable characteristics of the Eumenidæ.

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University Experiments with Sand Fly and Pellagra.

An account of endeavors to substantiate the Sambon theory of the transmission of pellagra by the sand fly, *Simulium*.

BY S. J. HUNTER.

THE etiology of pellagra has been a subject of serious inquiry for over two hundred years. Formerly an old-world problem, it is now found widely distributed in this country. The date of its first appearance in North America is not well established.

Three theories have been advanced as to the cause of this disease: (1) The zeistic theory, based on the work of Ballardini, in 1845, giving corn poison due to the excessive use of corn products as the cause, supplanting the old theory of faulty metabolism; (2) the cottonseed products poison theory of Mizell, in 1911; and (3) the sand-fly theory of Sambon, dating from 1910. The first two rest on malnutrition; the last on the action of a parasite.

Since this paper deals only with the parasitic theory of Sambon, the grounds on which Sambon bases his theory may properly be outlined here:

A. The endemic centers of pellagra in Italy have remained the same since the disease was first described.

B. The season of the recurrence of pellagra coincides with the season of the appearance of the full-fledged sand fly, even to the extent that if the spring is early or late the sand fly is early or late in appearing, and pellagra cases are correspondingly early or late in their appearance.

C. In centers of pellagra infection whole families are attacked at times simultaneously.

D. In nonpellagrous districts the disease never spreads to others with the advent of a pellagrin from a pellagrous district.

E. In the case of a family which has removed from a pellagrous to a nonpellagrous district, the children born in the former district are pellagrins, while the children born subsequent to removal to a nonpellagrous district do not develop the disease.

F. The disease is not hereditary, although infants a few months old may become infected, especially if taken to the fields in pellagrous districts, where their mothers work during the season when sand flies are in evidence.

G. Pellagra is not contagious but is transmitted to each individual by an infected sand fly.[1]

In Kansas the latter part of July, 1911, the first authentic cases, those of a mother and child, were diagnosed by Dr. E. E. Liggett, of Oswego, the attending physician. Dean Crumbine, of the medical school of the University of Kansas and secretary of the State Board of Health, expressed an earnest desire to have the presence of the sand fly ascertained for that locality. Accordingly the author began, on August 1, a survey of the region. The streams were high and muddy from recent rains, so that adults were first sought. An extended opportunity which I enjoyed for study of this insect some years ago in the Mississippi valley, between Keokuk and Fort Madison, Iowa, rendered familiar the workings of the adult females on horses, especially young colts, on which after warm rains the attacks were so numerous and severe as to denude the animals' ears and throats, exposing patches of raw flesh.

At the beginning of this investigation there was only one *Simulium* in the University collection recorded from Kansas. The investigation then from the beginning has been prosecuted along three lines: (1) The survey on the distribution of the sand flies in Kansas; (2) a detailed investigation of their life habits and conditions under which they exist in Kansas; (3) their biting and feeding habits and the possibilities of inoculation.

The first two lines have been treated in the following paper (No. 9) by my graduate student, Mr. W. T. Emery, who has been my assistant throughout these experiments. The third

1. Sand-fly Transmission of Pellagra, The Journal A. M. A., Nov. 26, 1910, p. 1898.

subject requires the consideration of the digestive tract, and this Assistant Professor Hungerford has presented in paper No. 10, of this number.

The Thompson-McFadden Pellagra Commission, with headquarters at Spartanburg, S. C., is conducting an exhaustive survey into all possible factors which might reveal the cause of this disease, and the Bureau of Entomology is coöperating with this commission along entomological lines. The department of entomology at the University is concerned only with the entomological side of the question, and has thus far dealt only with the sand fly. The responsibility for the entomological side of the question rests with the author, and the pathologic side, as manifested by the monkeys subjected to the bite of the sand fly, rests with Dean Crumbine of the medical school. In this connection it might properly be noted that recently Doctor Harris has published an article in which he states he has been successful in producing pellagra[2] experimentally in monkeys. Based upon his experiments, then, the monkey becomes a susceptible animal.

The line of investigation followed was: transfusions on guinea pigs and monkeys, and transference of flies, exposed to the pellagrins, to monkeys and guinea pigs. In the experiments with each exposed animal there was a check or unexposed animal.

The transfusions and inoculations gave no positive results. Temperatures of the guinea pigs and monkeys were taken twice a day without any appreciable change. As this subject has been covered in a paper by Anderson and Goldberger,[3] who obtained similar results, we will pass to what we consider the more important phase of the Sambon theory, viz., the role of the sand fly.

His theory is protozoal, and, from analogy with the etiology of malaria, the parasite of pellagra in all probability would have to pass one stage in the body of its intermediate sand-fly host before it could resume its life in the human body. This hypothesis being true, transfusions obviously would be without results.

Taking up the sand fly, then, the only species found generally distributed in Kansas thus far is *Simulium vittatum*, as determined by Johannsen. *S. reptans* is the species referred to

2. Jour. A. M. A. Lx. No. 25, June 21, 1913, 1948-1949.

3. Public Health Rep., 1911, XXVI, 1003-1007.

by Sambon, and reported on this continent from Greenland only. Since several species of the genus *Anopheles* transmit malaria, it would seem permissible to consider another species belonging to the genus *Simulium* than that of *S. reptans*, referred to by Sambon. *S. vittatum* is distributed in Kansas, as shown by Emery in a map in the following paper.

For the location of the pellagrins we have Allen, Chautauqua, Montgomery, Labette, Shawnee, Sumner and Meade counties. All cases are in the midst of the sand-fly territory, except the Meade county case, and this man, a resident of that region for twenty years, spent the year of 1910 in the South. The Allen and Labette county cases are endemic. None of these patients have ever been out of the state, so it would seem that the cause now exists in the state.

For our experimental work in 1911, the Oswego pellagrin, a woman aged about 35, now in the second season of the disease, was used, and she very willingly did her part.

In all, 1282 live sand flies were used, and this phase of the work extended from August 21 to November 4. The plan was to divide the number of flies intended for each experiment into two lots, the one lot to be exposed to the pellagrin and then to the subject of experimentation, and the other exposed to the check.

Ten guinea pigs and two monkeys were used, and the temperature of all was taken morning and evening daily. The number of live flies exposed to the pellagrin and then to the guinea pigs was 499; the number of live flies exposed to the pellagrin and then the monkeys was 197. A part of those exposed to the pellagrin were reserved for fixation and sectional microscopic examination in the laboratory. Since only the females bite, the relative number of the sexes is important. In a count of 488 specimens, 219, or 42 per cent, were females.

Earlier in the season the flies did not seem to bite the patient, but beginning with October 12 they attacked her, biting freely, drawing the blood perceptibly from the pellagrin's arms. These flies were then divided, part placed in the flyproof cage with the male monkey; part with the guinea pigs. Repetitions of the same experiment were made almost daily during the stated period.

This closed on November 2, 1911, the work at Oswego, Kan., and it was transferred from Oswego to the University labora-

tory. On November 7 the male monkey used to receive inoculation became suddenly ill, growing flaccid and motionless, save for a high rate of respiration. He was later placed in charge of Doctor Boughten, pathologist, and Doctor Skoog, neurologist, of the University. He was chloroformed, autopsied, and the brain and spinal cord were studied by Doctor Skoog. This monkey was taken from the University hospital group. It now appears that some eighteen months before this monkey was exposed to poliomyelitis. While the time is remote, nevertheless the exposure obviously introduces a complication which will make it unsafe to depend on this instance, unless substantiated by many pure culture corroborations.

This closed the work for the year 1911, and as far as our knowledge goes is the first recorded instance of an endeavor to apply the Sambon theory in this manner.

The following year, 1912, the same method of work was conducted, and to avoid any possibility of contamination six monkeys were imported direct from India for this work.

The season previous the flies were very abundant. The season of 1912 they were notably rare, due principally to the flooded conditions of the creeks in the northern part of the state and improper amount of moisture in the southern part of the state. The almost total absence, therefore, of flies in July, as well as a want of pellagrins in the proper stage, prevented any successful inoculations at that time.

From the fall brood, however, inoculations were made without waiting for the flies to bite the monkeys, but securing inoculations through maceration attended by the proper aseptic precautions. The last inoculation was made on a female monkey on December 16, 17, 18, 1912, using flies that had emerged on the 12th and bitten the pellagrin on the 14th.

Work for 1913 was conducted under a special fund furnished by the Board of Educational Administration.

Special attention has been given this season to the biting habits of *Simulium* in nature. Heretofore we have experienced little difficulty in encouraging the sand fly to bite the patient, but no extended study had been given to the biting habits in nature.

During 1912 it was found that they would bite during the mornings and evenings, sometimes entering the tent. The season of 1913, however, was not favorable in Kansas for the development of the sand fly during the summer.

In August, therefore, this part of the study was transferred to Madison river, in the southern part of Montana, where all stages of the fly were unusually abundant. Here it was observed that the fly would bite the exposed parts, and was more active on cool days while the temperature was below 70° F.

Of special importance was the observation made by four members of the party that the bite of the fly was not always noticeable. For example, the writer sat through an entire evening meal in the tent with the sand fly biting on the face near the base of the nose. He was not aware of its presence there until informed at the close of the meal by his companions regarding the length of the time it had been there. The spot reddened in this case was about the size of a flax seed.

It seems probable also that it succeeds in attaching itself to the host through its mouth parts, because when once settled down to feeding it sticks to the host and is not readily detached.

Biting is not uniformly painless, as sometimes the insect could be detected by its first contact.

Regarding the morphology of the mouth parts, Mr. W. T. Emery, who has been my graduate student assistant in this work, has the paper following, dealing with that phase of the subject.

A second point to be here recorded is that the monkey, which we used all last year to receive inoculations from the sand fly, and which received its last inoculation on December 22, 1912, as recorded in my previous paper, late in November, 1913, began to show a marked stomatitis, accompanied by a diarrhœa. She has continued to lose in weight and the color of the face is changing from the normal to a pale ashy gray.

Summing up the evidence, then, in the work thus far for and against the Sambon theory:

1. The number of sand flies has been directly proportional to the number of cases of pellagra.

2. The first appearance of the cases of pellagra is coincident with the principal broods.

3. Just succeeding the time of the principal broods the flies appear to bite more vigorously.

4. Sand flies which have fed on human blood live several days longer than those which have not been so nourished, thus favoring an incubation period for a parasite, if such there be.

5. Pellagra, thus far in Kansas, has appeared almost entirely in one restricted locality. Of the nine cases recorded last year five were traced back to one town. In this region flies are widely distributed and unusually abundant.

6. No direct evidence has thus far been found which would in any way warrant any conclusion with reference to an association of the sand fly in the determination of the etiology of pellagra.

As far as our history of this subject goes, the appearance of pellagra in Kansas is of recent occurrence. Nearly all of the cases are those of natives that have never been out of the state. From this it would seem that the etiology of pellagra exists 'n Kansas.

The situation here is not complicated through long-standing conditions. It is the purpose, therefore, to continue this phase of the work, and with it the correlation of the clinical and pathological phases by the medical school of the University.

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The Morphology and Biology of *Simulium vittatum*

AND ITS DISTRIBUTION IN KANSAS.

BY W. T. EMERY.

Plates XXXVIII to XLII.

Submitted in partial fulfillment of the requirements for the degree of master of arts.

PREFACE.

THE following paper was written from the data and material collected as a result of a request from Governor Stubbs of Kansas, 1911, through the State Board of Health, and Dr. S. J. Crumbine, dean of the school of medicine, and Prof. S. J. Hunter, professor of entomology, at Kansas University, to locate sand flies (*Simulium*) in their geographical location to pellagra cases in the state.

Here I wish to thank Prof. S. J. Hunter for his kind assistance in conducting the investigations, and for his many helpful suggestions in working out the problems, both in the field and in the laboratory. We are indebted to Dr. O. A. Johannsen for determining the species *Simulium vittatum*. Mr. H. B. Hungerford was kind in helping me secure literature on *Simulium*. I also appreciate the assistance of Messrs. F. X. Williams, A. E. Mallory, E. C. O'Roke and H. R. Jennings of the Kansas Biological Survey of 1911, for collecting specimens of *Simulium* and observing their habits and breeding places. I thank Dr. Grace M. Charles of Kansas University botany department for determining the algæ in the alimentary canal of *Simulium* larvæ. Mr. L. M. Peace made the photographs of the *Simulium* figures used in the text.

Morphology and Biology of Simulium vittatum and its Distribution in Kansas.

On casual observation *Simulium* flies are about the size of the common fungus gnats (Mycetophilidæ) which we often see on a piece of apple peeling or on decaying fruit. However, upon closer examination they are found to be distinctly different both in form and color. These little flies are gray to black in color and are from two to four millimeters in length, depending on the species and sex. They have a conspicuously prominent thorax, hump-backed in appearance, and their heads are drawn down in front of them. This latter characteristic adds to the prominence of their thorax, so much so that they have received the popular name of buffalo gnats. In the South they are called turkey gnats, in the North black flies, and in Europe sand flies.

Perhaps the most conspicuous characteristics of *Simulium* flies are their comparatively heavy cone-shaped antennæ that protrude from between the eyes at the base, diverging like a pair of horns. They are about the length of the head, ten jointed, with the joints closely articulated except the two basal ones, which are differentiated. Other noticeable characteristics are their relatively broad and slightly veined wings, their prominent thorax, and the structure of their mouth parts.

The latter to be seen well must be dissected and placed under a compound microscope. These I shall describe further on in the paper. At the time of emergence their eyes have a reddish tinge. They have no ocelli. Compared with other flies of their size the legs are thick and heavy set.

LIFE HISTORY—HABITAT.

Nearly every one has observed mosquito wigglers in rain barrels and pools of standing water, but unlike this habit of mosquitoes, *Simulium* flies breed only in running water, such as ripples and waterfalls. It seems that its aquatic larval nature demands well aërated water if it is going to live and complete its life cycle. For instance, if a *Simulium* larva is placed in a vessel of standing water it soon dies, apparently for the want of sufficient oxygen. When *S. vittatum* is washed from the rocks in shallow ripples into deep water it will drown, unless it floats with the current to another ripple or waterfall where it can attach itself to a stone or vegetation.

As a rule, in regions where *S. vittatum* occurs the larvæ are found in the ripples and falls of creeks and small streams, not rivers, that flow the year round. The most essential condition for the well-being of these aquatic creatures is rapid motion of the water in which they live. Not only did the writer find this to be the condition, but in the Kansas Biological Survey notes for 1912, Mr. E. C. O'Roke writes, at Hays City: "While scouting about for a camping place we observed larvæ and pupæ of sand flies on a concrete dam and on the rocks below it in Big creek." In another part of the notes Mr. A. E. Mallory, at Rush Center, says: "We found many *Simulium* larvæ and pupæ in the ripples." In the same field notes Mr. F. X. Williams, at Ness City, writes: "In a small branch of Walnut creek, where the ripples are weak and the bottom is pebbly, but with no stones, I found *Simulium* larvæ, pupæ and eggs plentiful on the sedges lying flat in the ripple." This last note shows that while there were no stones to break the flow of the water, yet the sedges, on which the *Simulium* lived, were washed by the current.

As to the character of the water in their breeding places, it is generally clear and well aërated, though sometimes it contains considerable organic matter. Two of the breeding places observed in Kansas where the flies were very numerous were streams that carried sewage. One was at Rosedale, Kan., a suburb of Kansas City, and the other was at Oswego, Kan. Doctor Forbes, of Illinois University, states, in his report on *Simulium* of that state, that the larvæ were found in the sewage drains far up into the city of Chicago.

Since their habitat is in ripples or in places where the water is accelerated by an obstruction, it is interesting to observe what takes place in standing water. Our observations in the laboratory showed that they died in about an hour; at least they would not respond to stimulation after that time in a vessel of water. Consequently, in a stream when the larvæ are swept into quietly running water, they drown unless they can maintain themselves in the current long enough to float to another ripple. In a little stream near Oswego, in which there were two ripples about fifty yards apart, the second ripple or the one below was narrowed so I could observe approximately the number of larvæ on the stones. After disturbing about fifty or more larvæ in the upstream ripple,

causing them to let go their holds on the rocks and drift into the quiet slow-running water, I was unable to detect any increase in the number of larvæ in the small narrow ripple below. However, after a rain which caused a swifter current between the ripples, I could sometimes find more larvæ than usual in the lower ripple. Ordinarily the current was sluggish between the ripples.

From our observations, there are three principal broods of *S. vittatum* each year. One occurs in early spring, the fore part of April; one in mid-summer, from the middle to the latter part of July; and one in mid-autumn, the latter part of October, the time for these broods varying with the earliness or lateness of the seasons. The general time for the spring and fall broods seems to be at the heavy frost-line period. This period varies with different species and in different states.

Mr. Otto Lugger, the state entomologist of Minnesota, in his report of 1896, pages 201 and 203, says in part on *Simulius* flies: "The first species seen and felt occurs early in the spring soon after the snow disappears. This species (name not given) flies from May 13 to June 1. A little later in the season, but chiefly during June and July, a somewhat larger species, *S. decorum* Walker (synonymous with *vittatum* Zetterstedt, according to Coquillett) becomes numerous." Mr. C. V. Riley, in the report of the United States Entomologist for 1886, pages 342 and 343, refers to Mrs. Sara J. McBride, of Mumford, N. Y., as stating in one of her articles that "the perfect flies issued about April 1st." In the *American Journal of Science,* volume I, 1913, under the heading, "A Destructive Insect," mention is made that, "Contrary to the custom of other insects, it (*S. pecuarum*) always appears when cold weather commences in December, and as invariably disappears on the approach of warm weather, which is about April 1 (Choctaw county, Mississippi), and continued to return at the same season from year to year."

In the report of the Commissioners of Agriculture for 1886, Entomologist C. V. Riley says, in speaking of the southern buffalo gnat (*S. pecuarum*), as to its time of appearance: "The first swarms were observed last year in Louisiana on March 11, in Mississippi and Tennessee May 1, and in Indiana and Illinois May 12. Small local swarms may appear somewhat earlier or later in the neighborhood of their breeding

places. The turkey gnat (*S. meriodionale* Riley) appears usually later, although in 1886 it appeared near Memphis, Tenn., as early as April 5. The swarms were quite local, however, and strictly confined to the vicinity of the creeks that produced them. The greater majority of the species of this genus are northern insects, and appear there in the winged form all through the summer. The larvæ require cold water for development. As we go farther south the cold water can only be found in the more elevated regions or in winter or in the earlier months of spring. Earliness of season or high altitude are the substitutes for the lower temperature of the more northern latitude." All this goes to show that the time of the appearance of *Simulium* broods varies with different species and in different states.

That *S. vittatum* emerges throughout the summer is shown from my field notes on that species in our experiments to determine whether or not it is capable of transmitting the disease pellagra. We collected pupæ as they formed on the rocks, and placed them under a trap which was over the ripples so as to secure as many flies as possible (fig. 1). The following dates show uneven emergence of the flies from the breeding traps and how they increase in numbers as cooler weather approaches, until the creek freezes:

OSWEGO, KAN., 1911.

Date.	No. flies.	Temperature, F. Mx.	Mn.
Sep. 7	2	84	65
8	5	83	68
9	3	83	67
10	5	89	68
11	6	91	70
13	24	94	73
14	4	92	73
19	6	73	57
20	17	71	58
21	11	74	52
22	9	82	53
24	6	89	67
25	4	90	68
27	10	90	68
28	9	91	70
29	16	81	70
30	6	83	61

Oct. 2	70	90	65
3	70	88	71
4	100	78	58
5	150	84	60
6	120	83	62
7	54	63	51
8	150	65	48
9	105	61	50
10	60	69	43
11	40	81	54
14	108	85	57
16	40	77	46
17	56	71	43
18	22	73	45
20	4	55	40
23	25	68	30
24	5	69	37
25	12	67	45
26	12	73	36
30	2	53	34

February 15, 1912, Rosedale, Kan.—Full-grown *Simulium vittatum* larvæ covered the under sides of the rocks in the ripples in Turkey creek where it enters the city.

June 7, 1912, Rosedale, Kan.—*Simulium* larvæ were less numerous and smaller than those observed February 15. This is a good evidence that a brood must have come off early in the spring, leaving these stragglers to emerge later. Some of these later larvæ I placed in a ripple in the laboratory at Kansas University, getting them to pupate and emerge later. From a few pupæ that I brought to the laboratory at that time eight flies emerged on June 8. From the larvæ that pupated in the laboratory twenty-four flies emerged June 19.

Of the midsummer *S. vittatum* brood that emerged from a small stream on the University campus the following dates and number of flies taken were accounted for:

Jul. 13	40	flies.
16	15	"
21	2	"
22	1	"
25	3	"
27	3	"
28	5	"
29	4	"
Aug. 4	2	"
5	2	"
7	2	"

Observations on *Simulium* could not be carried through the summer at Rosedale nor at Oswego because the streams at those places dried up during the drouth, and as a consequence the *Simulium* there ceased to propagate themselves.

The following number of *Simulium* flies were trapped in the Little Arkansas river at Wichita, Kan.:

Nov.	10	12 flies.
	11	5 "
	12	33 "
	13	20 "

Simulium flies may emerge during a warm spell in the winter, as our experiments in December, 1912, show. My field notes read as follows: "Dec. 11, Wichita, Kan.—Took 50 to 60 *S.* pupæ from partly frozen river and placed them in a laboratory, using city water. Dec. 12.—14 *S.* flies emerged. Dec. 13.—10 *S.* flies emerged."

A moderate or cool temperature seems to affect not only the length of an individual *S. vittatum* fly's life, but also its biting habits or blood-thirsty nature. "If cold weather follows their appearance, the gnats become semidormant; they are not killed by it nor by rain, but revive and become aggressive again with the first rays of the sun. Hot weather, however, soon kills them."[1]

During the months of September and October, 1911, we used over 1200 flies in our experiments with pellagra. Not until the cooler weather, the later part of October, did we succeed in getting the flies to bite. At this time the temperature was about 20° cooler than when they had refused to bite. According to the local U. S. government weather station, the temperature frequently ran above 90° in September, with an average maximum of 86.1° and minimum of 65.7°, while in October, at the time of biting, the maximum was 67° and the minimum was 45° F. Again in the middle of November the following year, 1912, I caught *S. vittatum* at Wichita, carried them over 150 miles to Topeka, and succeeded in getting them to bite. One month later I took *Simulium* pupæ from the Little Arkansas river, which was partly frozen over, placed them in a laboratory with water running over them at a temperature of 60° F., and secured twenty-four flies. They were then taken about 200 miles to Parsons, where we succeeded in getting four of them to bite a supposed case of pellagra. (Only sixteen flies, one-half of which were males, made the trip).

Before this time I had supposed that perhaps the flies had to oviposit before they would bite, but from the above experi-

1. Dept. Agri. 1886.

ments it appears to be a matter of stirring them to that activity by the proper temperature during their life cycle. At no time have I been able to find eggs deposited on the rocks underneath the traps where the flies emerged that did the biting. Literature on the subject of their habits of biting refers to them as being the worst to bite in early spring and late fall, in the early morning and on cold rainy days. The argument in the U. S. Department of Agriculture Year Book, 1886, quoted in bulletin 5, 1896, is that *Simulium* flies oviposit before going out in swarms to seek warm-blooded animals, that when once gorged with blood they soon die, and that microscopical examinations have failed to reveal any eggs in the ovaries composing these swarms, therefore they evidently oviposit before biting.

Our experiments brought out the fact that *Simulium* will bite in captivity and in houses, also that they can be shipped long distances and kept alive for two and three days without feeding. As for keeping *Simulium* alive in captivity, the males died soonest, living one to two days, while the females would live two to four days. When filled with blood (human) we kept one female alive seven and one-half days, from Friday afternoon of one week until Friday morning of the following week, at which time the fly was destroyed in our experiments. Just how long they can be kept alive by refeeding I do not know. They are said to feed on maggots and caterpillars. (British Diptera, p. 165.)

It is interesting to watch the flies oviposit on the stones in ripples. The female selects a stone in the ripple where a film of water seeps upon the lower downstream side in very small vibratory waves. In these tiny waves she places the tip of her abdomen and wings and deposits from 200 to 300 eggs strung back and forth as she moves along, in rows close together so as to form a mass, usually from one-fourth to three-eighths of an inch long and from one-sixteenth to one-eighth of an inch wide. Here the waves constantly wash the tip of the abdomen and afterwards keep the egg mass moist. From five to ten minutes is spent in the process. In midstream, where the current made the small waves best, several egg masses were piled upon one another and alongside adjoining, sometimes covering the whole downstream side of the rocks. Frequently a fly would cease ovipositing and go away to finish on another rock or perhaps to return to finish on the same rock.

Some of the eggs were laid on old leaves in the ripple. N. Y. St. Mus. Bul. 47, p. 408, gives the following on oviposition: "The place selected is always at the edge of a little waterfall, on a surface that is intermittently washed by the swaying current, and so kept wet. Here the females flock and pile up great white masses of eggs, which with a little age turn yellowish. Waves dash over them while ovipositing, and often sweep them away, but they at once return to their task."

The description of an egg mass is given in my field notes for October, 1911, as follows: "*Simulium* eggs when first deposited are whitish or creamy in color. In two or three days they begin to turn yellowish, becoming later a rusty yellow, then brownish to a dark brown, almost black at time for hatching. All this time they retain a shiny appearance. The empty shells after the larvæ have hatched look dull, tattered, torn, and sunken in, soon breaking to pieces in the rippling water. When first hatched a larva is so small and light in color that one can hardly see it on a rock with the unaided eye. On account of the reflections of a wet rock it is even difficult to see with a 12$\times$ lens if the larva is not moving."

A variation in the length of the incubation period is shown in my field notes. "October 26, 1911.—Discovered very small larvæ, 1 mm. long, on rock with egg mass that I found October 19. Yesterday the eggs were full; to-day many of them were sunken in. October 28.—Found more small larvæ on rock with eggs discovered October 19. October 30.—Part of the eggs laid on the rock that I placed in the ripple for that purpose October 23 are rusty yellow and very shiny. November 2.—Creek partly frozen over. Eggs of October 23 apparently still unhatched, but covered with a dirty slime like empty shells. Part of them were hatched, though I could find no young larvæ with them.

The dates from October 19 to 26 show a period of eight days, while that from October 23 to November 2 shows a period of eleven days for incubation. That variation is due, no doubt, to the decrease in seasonal temperature to freezing.

Now the length of the larval stage may also vary. Taking the periods between the broods previously mentioned—that is, from the fore part of April to the middle of July, and from mid-July to the latter part of October—we find the length of life cycle during the warmer months to be approximately three months and one week. Allowing five to six days for the

length of the pupal stage, as we observed it in September, 1911, and eight days for the incubation of the eggs, we get the length of the larval stage in the warmer months to be about two months and three weeks. For the life cycle of the spring brood, that leaves a period from the latter part of October to the first part of April, or about five and one-half months. Since it is in the larval stage that they winter over, it would indicate that the winter temperature prolongs the length of the larval stage for the spring brood.

Newly hatched larvæ are a pale creamy color, and about one millimeter in length. They possess indications of the same general characteristics of form and structure that the full-grown larvæ have. The color soon darkens to a slaty green.

A full-grown *S. vittatum* larva measures from five-sixteenths to three-eighths of an inch in length. The body is somewhat attenuated in the second abdominal segment and gradually increases in size in the third, fourth, fifth and sixth segments. Beginning with the seventh segment there is a much increased or abrupt expansion that gives the larva a widened and flattened appearance.

The metathoracic and mesothoracic segments and the first six abdominal segments are cylindrical. The prothoracic is thickened dorso-ventrally by the attachment of the single prothoracic leg. (Plate XXXIX, fig. 11.) The head is semi-flattened, with a slightly constricted neck, and is about the length of the thorax.

On the head are some very unusual prehensile organs, used to collect food from the rippling water. They are fan-like in shape, with forty filaments or rays in *S. vittatum.* (Pl. XLI, fig. 31.) When disturbed, or when the larva is taking food from the rays with its mandibles and maxillæ into the mouth, the fan is closed so that the tips of the rays come just to the oral opening. These rays are scythe-shaped, ciliate on the inner side, with longer setæ at regular intervals. (Pl. XLI, fig. 31.) The rest of the mouth parts, labrum, mandibles, maxillæ, hypopharynx and labium, together with the antennæ, are shown individually and compositely arranged on plate XLI, figures 32-35. Between the fans are the slender five-jointed antennæ; the fifth joint is a pointed process at the end of the fourth. Back of the fans on each side of the head are two narrowly separated black spots. These may be eyes, or light organs. Besides the leg or foot, on the sides of the

thorax there appears on the full-grown larva black spots which are the pupal gills, folded and drawn up beneath the skin.

At the caudal end is a sucker-like aperture used to hold the larvæ to the stones and debris in the ripples. It is made up of a series of rows of tiny hooks. On the dorsal side the sucker-like organ is produced into a V-shape. (Pl. XLI, fig. 35A.) Cephalad of this are the breathing gills. In *vittatum* these are three-branched, as membranous sacs, finger-like, when the larva is undisturbed in the water.

In preserved specimens the gills can not be seen unless forced to distend by pressure from a dissecting needle placed cephalad of them.

The larvæ intermediate in size appear to seek the swifter ripples, while those about ready to pupate and the smaller ones seek the less violently agitated parts of the ripples. When moving about on the stones they have a looping motion, similar to that of a geometrid larva. They more frequently make their looping motion laterally instead of dorsally. In doing this they first attach their thoracic leg, then draw their caudal sucker forward and attach it. Frequently one can see the silken thread they spin as they move about. It looks as though they always kept the thread attached, because at any time they are washed from the stones or debris they will float away from one to ten inches, holding fast to the thread, which they spin as they go.

The larva possesses two silk glands, laterally placed, extending about three-fourths the length of the body, then recurved, U-shaped, extending back to the thoracic segments. The outlets are the two ducts which lead into the hypopharynx.[2] Besides being used as a means of security, the thread is used to float out in the ripple while feeding, and for building the pupa case. Ordinarily, while feeding, the larvæ attach their caudal sucker to the object in the ripple and let the rest of their body and head float at an angle of sixty to ninety degrees. I have watched them in the water draw their fans in and scrape them with their mandibles as though collecting food.

With the kind assistance of Dr. Grace M. Charles, of Kansas University, we found several species of diatoms and the following kinds of algæ in the digestive tract, which I take to be the food of *S. vittatum: Conferva, Scendesmus, Chlanydomo-*

2. N. Y. St. Mus. Bul. 68.

nas, *Engrena*, and *Charcium*. Besides these I found several kinds of bacteria in a smear made from the alimentary tract of a *Simulium* larva.

"According to the unpublished observations of Miss R. Phillips (of the class of 1890, Cornell University) the larva feeds on algæ, as *Nothix*, *Chaldophora*, *Vaucheria*, on diatoms, and parts of phanerogamous plants. Sand also has been found in the digestive canal." (N. Y. St. Mus. Bul. 68.) "A searching investigation of the water in their breeding places revealed the fact that it was swarming with animal life and was filled wih the larval forms of small crustaceans belonging to various families, but chiefly to those of copepods and isopods. Larvæ of the southern buffalo gnat (*pecuarum*) kept in glasses were observed to swallow these minute crustaceans, and none of this food was seen to be expelled again. A number of square diatoms, jointed together in a chain, have also been observed by the aid of the microscope." (U. S. Dept. Agri. Yr. Bk., 1886, quoted in Bul. 5, n. s.) The above would indicate that *Simulium* larvæ are both herbivorous and carnivorous.

A very interesting part of *Simulium* larvæ's and pupæ's habits was learned when we discovered their ability to keep alive in a wet pack of cloth or snow for several hours. Our first experiment with that was on February 15, 1912, when I packed some *Simulium* larvæ, on the rocks, in wet snow wrapped in cheese cloth. The time of packing was 5 P. M., the place Rosedale, Kan. From there I transported the mass in an old suitcase to Lawrence and placed them in a ripple in the laboratory at 8 P. M. The snow pack was frozen when I unpacked the larvæ, but they were active and continued to live afterward in the laboratory.

The next time we tried that experiment was June 7, 1912, when I packed the larvæ and pupæ on rocks in wet cheese cloth at Rosedale at 5 P. M., brought them to Lawrence and placed them in the laboratory ripple alive at 11 P. M. Some of the larvæ left in the wet cloth were still alive at 10 A. M. the next day, June 8. This made a total of seventeen hours that the larvæ kept alive in the wet pack. The pupæ continued to live, so that imagoes emerged June 14. The larvæ soon transformed to pupæ, and twenty-four flies emerged June 19.

Again on August 3, 1912, I brought to Lawrence from Rosedale several pupæ torn from the rocks and several larvæ off the rocks in a wet pack in a tin box. Those larvæ lived

through that ordeal all right, and two flies emerged from the pupæ August 4. However, at this time the Lawrence city water was so impure that they were using strong chemicals to purify it. This seemed to kill the larvæ, so that they were all gone from the ripple August 5. No more flies emerged from the pupæ. Larvæ newly hatched from the eggs in the laboratory ripple soon died. On July 2, I placed *Simulium* eggs in the laboratory ripple, and on the 5th and 7th I found newly hatched larvæ, but the city water seemed to kill them after hatching; at least they disappeared.

Our experiments had been so badly interfered with in the laboratory by drugged water, and the several streams in the state where we were conducting experiments went dry during the drouth of the summer, so that our experiments looked dubious. Fortunately I located a good brood of larvæ in the Little Arkansas river at Wichita. Knowing that *Simulium* breed in sewer ditches, and desiring to establish a permanent brood near our laboratory, I decided to take a number of the larvæ from the stream at Wichita and place them in the sewer exit, in good ripples and a fall, at Lawrence where it empties into the Kaw river. On October 8 I collected several hundred nearly grown larvæ, from 4 to 5:30 P. M., transported them in a wet pack off the rocks to Lawrence, where I placed them alive in the sewer at 7:15 A. M. October 9. October 10 a lot of the larvæ had disappeared. October 11 most of the larvæ had disappeared. A piece of cloth that I had left in the sewer with larvæ on it smelled strongly of kerosene and had a white sediment on it. The rest of the larva soon disappeared. Since that time I have succeeded in keeping a *Simulium* larvæ alive in a tin box with a wet cloth for more than seventy-two hours.

Simulium pupæ, when first formed, are a yellowish brown color, later becoming darker as the dirt in the water discolors them and as the imago develops within the case. With the filamentary breathing gills a pupa measures about one-eighth of an inch long. (Pl. XXXIX, fig. 7.) Their gills or respiratory filaments arise from a common base on each side. In *S. vittatum* the base of one gill divides into two, and from each of these arise four branches, these again each dividing into two, making sixteen tracheal filaments for each gill.

According to observations made by Miss Phillips and recorded in her thesis, 1890, the spinning of the cocoon of

S. pictipes is described as follows: "In spinning, the thread issues from the mouth and is placed in the different positions by the thoracic proleg. The head is bent down, and with the proleg the thread is drawn around the body, except the head. The skin of the head is then cast off, and the insect then pulls itself out of the skin of the body, leaving it whole. The cast skin may often be found in the cocoon with the pupæ. The cocoons are commenced at the upper margin and spun continuously down to the caudal end, where several threads are drawn from the cocoon and attached to the last one or two of the body segments of the pupæ. The threads hold the pupa very firmly and are always found when the pupa is pulled out of its case.[3]

I found it very difficult to watch *vittatum* spin their cocoons, because the adult larvæ almost invariably go to the under side of the rocks and debris or seek a protected place in the ripples for pupating. *Vittatum* pupæ are, when first formed, drawn back into their cases so that only the pupal gills show from a dorsal view. Inside of a day or two they begin to push out a little, showing the head bent down and the origin of the gills. On the fifth day after pupating I observed some pupæ that had swung free from their cases and faced in the opposite direction alongside of them.

They were still attached by two threads that ran into the pupæ cases. A description of the same habit of slipping from their cases is given in the United States Department of Agriculture Year Book, 1886, p. 508. We observed a pupa in a vessel of water turn over in its case. It was seen to do this several times, always turning on its ventral side.

When the pupa is drawn from its case, upon close examination one can see two small black blunt hooks on the dorso-caudal end of the pupa, and eight similar hooks on the dorsal front marginal side of the abdominal segments, four in a row on each side, parallel to the margin of the segments; they are a part of a membranous covering as shown in plate XXXIX, figure 9. By means of them it attaches itself to the silky threads of the pupa case.

A general external view of the individual pupa on a rock is shown in plate XXXIX, figure 7. One can see the origin of the pupal gills, and the head tucked beneath, also the prom-

3. N. Y. St. Mus. Bul. 68.

inence of the thorax within the case. Plate XXXIX, figure 7, shows a pupa with the imago within more developed and its habit of withdrawing from the case as it matures. Plate XXXIX, figure 8, shows a newly formed pupa removed from its case. This shows the wing pads in their early development. Plate XXXIX, figures 7 and 9, show lateral and dorsal views with the wing pads more developed.

Emergence of the Adult.

It is very interesting to watch the fly emerge from its pupal skin. The skin is split longitudinally on the fore part of the hump of the pupa. First the fly gets its head and fore legs out, then by pulling itself forward it gets the middle legs and part of the wings out, continues to crawl forward, freeing its wings, hind legs, and abdomen. The whole process took about five seconds on a stone that I held in my hand out of the water. It left the old pupal skin fast in the case with the respiratory filaments intact.

Empty skins soon wash out of the their cases, which are left as little tough empty pockets to fill with dirt and eventually be washed away.

Mr. E. C. O'Roke, in his field notes of the Entomological Survey, 1912, writes the following about newly emerged *Simulium*: "They would dry their wings about five seconds, then fly." He watched them emerge from a board which he held out of the water. On the same survey Mr. F. X. Williams notes: "Almost immediately on reaching the surface (of the water) the fly (*S. vittatum*) would make efforts to rise on its still flexible wings; sometimes, being unable to do so immediately, would skim along the water for a way." His notes continued to say that unless they arose after skimming and floating around a short time they were devoured by some small fishes a few feet below the place of emergence. Mr. H. R. Jennings, on the same survey, notes: "The adult fly would first show up on the surface of the water, having emerged from a pupa case among the spirogyra, and then passed to a place free enough from spirogyra to allow it to come to the surface. Once at the surface, the fly would float on down the stream until it caught on the spirogyra, and was there able to wait until its wings were thoroughly ready before attempting flight, or, if carried by the current into a place free of spirogyra or other surface obstructions, the fly would, when permitted to float upon the surface

of the water, wait until ready for flight." This shows that the flies do not take flight immediately after emerging from their pupæ, either when in the open air or when emerging beneath the water. Instead, they wait a short time for their wings to dry and harden.

Predaceous Enemies of Simulium.

Like most insects, *Simulium* flies have their predaceous enemies, and may have some parasitic ones, though little is known of the latter. U. S. Dept. Agri. Bul. 5, n. s., 1896, gives an account of some of the natural enemies of buffalo gnats, as follows: "But few birds have been observed to feed upon them, though for the southern forms, the mockingbird, winter wren, and especially barnyard fowls, after the flies become gorged with blood, feed upon them. Dragon flies (Libellulidæ) and robber flies (Asilidæ) have been observed to catch them. The larvæ are devoured in large numbers by the smaller fishes, minnows, etc., and probably the carnivorous beetles, bugs, and other aquatic insects prey upon them."

Perhaps the best observations of predacious enemies of *Simulium* larvæ, says in part: "I observed some small carabid by Messrs. E. C. O'Roke and H. R. Jennings on their Entomological Survey of 1912. Mr. O'Roke, in writing about *Simulium* larvæ, says in part: "I observed some small carabid beetles, the kind you see along mud on stream banks all over this section of country (Ellis county), feeding on the sand-fly larvæ. Two would take hold of a small larvæ and pull it much like two chickens pull an earthworm. This was after I had removed the larvæ from the water on a stone."

Mr. Jennings, in writing of the chances a sand fly has of getting away from the water upon emerging from their pupæ where fish exist, says in part: "Any fly unfortunate enough to remain on the surface until the water was deep enough for fish, and also free from algæ, was very certain of having an immediate and fishy grave. Repeatedly I saw flies disappear from the surface in this manner, and to make sure that it was not by flight, I crippled some of them and took care that they floated within reach of the fish, when their disappearance was both immediate and certain. In fact, very few flies which got into the current were allowed to leave the surface of the water in flight, and these few probably owed their existence to the fact that a strong wind was blowing directly upstream, and

hence against the current. This would frequently delay the downstream journey of the fly, and occasionally long enough for safety."

Mr. Williams said he saw a hydrobatid suck the life blood out of a fly. Here we have fish and beetles preying upon the adults and larvæ.

METHODS OF CATCHING AND HANDLING SIMULIUM FLIES.

Trapping *Simulium* flies is an interesting proposition from the nature of their habits and habitat. Ordinarily we can catch a great many kinds of insects with a net. In the case of *Simulium* flies, unless they are in swarms or are very numerous over the water, it is difficult to get many of them that way.

In order to carry on our experiments it was necessary to have them alive and in large numbers. Swarms of them were not to be found, and only a very few individuals were hovering over the ripples at any time. We at once decided to trap them in the ripples as they emerged from their pupæ, and thereby secure flies free from any contagion that might interfere with our experiments.

On account of the habits of the pupæ requiring simply moisture to keep their gills wet, I had good success getting the flies to emerge by placing stones with pupæ on them in straight running water, and then setting a trap over them. The trap consisted of a small wooden box about one foot deep, one and one-half feet wide, and two feet long, without a top. This was turned bottom side up and a hole eight inches in diameter cut in it. In this hole I tacked a cone made out of window screening covered with cheese cloth. Then by cutting notches in the ends of the box to let the water run through without leaving a hole for the flies to crawl out, the trap was complete. The box being dark inside, the flies upon emerging came up into the light in the cone and rested on the inside of it. Plate XXXVIII, figure 3, shows the structure of such a trap.

At first I tried the screening alone without covering it with cloth, but the flies crawled through the meshes and escaped. Another thing I tried was a small screen cone inside a larger cone, like one sees in traps used nowadays to catch house flies, but this inner cone was useless because the *Simulium* flies dropped back through the opening in the top of it when I tried to take them from the outer cone.

Now *Simulium* flies are stuborn creatures to handle, for the reason that frequently they seem unaffected by light stimuli, at least will remain in a darkened chamber instead of coming into the lighter one. It frequently took an hour to get a few flies to go from a cone in a trap, darkened by covering it with a double thickness of black cloth, into a lighter chamber. The flies were more active and much more easily handled in the early morning while it was cool than later in the day after the temperature had risen. The heat of the day seemed to make them sluggish and inactive, so much so that it was extremely difficult to induce them to go from one cage to another at midday. Again in the evening, when the heat of the day had subsided, they became more active. Literature refers to them as being a cool-weather fly, as most offensive with their biting in the early morning and on cool days. Other places they are spoken of as not biting in warm weather during the summer.

When *Simulium* flies move they generally go very quickly and fly with a great deal of force. At first we removed them from a trap into a glass bottle, but they flew against the transparent sides of the bottle with such force that it seemed to stun them. Their antennæ are comparatively large and protrude forward, so that, in flying against the glass, their antennæ, which are probably their sense organs of touch and perhaps of sound and smell, received a shock that seemed to make the flies more stupid. We then tried taking them into a gauntlet-shaped wire cage covered with cheese cloth. In this they had more room and softer walls to butt their antennæ against. Here they were more quiet and more easily handled.

Plate XXXVIII, figure 3, shows the method of taking them out of a trap into a bottle, except that we placed a black cloth around the cone to darken it at that time. We substituted the gauntlet cage for the bottle. In this manner, when the pupæ were numerous, we were enabled to secure plenty of flies for our experiments.

ECONOMIC IMPORTANCE OF SIMULIUM.

Considerable literature has been written on the depredations of "black flies," "buffalo gnats," "turkey gnats," and "sand flies" (*Simulium*) since the latter part of the eighteenth century, in Europe, and since the pioneer days of settlement in the Mississippi river valley of America. Theobold (British

Flies, vol. I, p. 165) says: "In England we do not suffer much from these flies, but in other parts of Europe they are very obnoxious; Schonbauer (Gesch. der Shadl. Kolumbatezermucken, Wien, 1895; and Kollar's 'Treatise on Injurious Insects,' p. 68) gives an account of one, *S. columbaschensis,* which is one of the greatest scourges to man and beast in the Bannat of Temeswar, in Hungary. Fries (Observ. Entom. [*Simulium*], Stockh., 1824; Fries) also describes the molestations of these 'sand flies' in Lapland."

In America accounts have been written from time to time on the ravages of the different species of *Simulium.* The black fly of the North (*S. molestum* Harris) has been described by Dr. A. S. Packard (Amer. Nat., vol. II, pp. 589-590) as even more formidable a pest than the mosquito, that in the northern subarctic regions it opposes a barrier against travel. "The Labrador fisherman spends his summer on the seashore, scarcely daring to penetrate the interior on account of the swarms of these flies."[4]

The southern buffalo gnat (*S. pecuarum* Riley) and the turkey gnat (*S. meridionale* Riley), in the lower Mississippi valley and tributary regions, and the western buffalo gnat (*S. occidentale* Townsend), along the valley of the Rio Grande, have been the cause of a great deal of suffering to humans by their bites, and the loss of hundreds of head of live stock, including poultry. Accounts of these conditions are given by Dr. C. V. Riley in the Year Book for 1886, U. S. Dept. Agri., Div. Ent., pp. 492-517; in Bul. No. 5, 1896, pp. 31-58; in later publications by O. A. Johannsen, 1903, N. Y. St. Mus. Bul. 68, Ent. 18, Aquatic Insects in N. Y. State; and by Dr. S. A. Forbes, State Entomologist of Illinois, 1912, "On Black Flies and Buffalo Gnats (*Simulium*) as Possible Carriers of Pellagra in Illinois."

Simulium flies, *S. reptans* in particular, have been accused of transmitting the human disease pellagra, by Dr. L. W. Sambon. Doctor Sambon formulated the tsetse fly theory of sleeping sickness, which has proved true. In 1910 he was detailed for three months in Italy, where he studied pellagra. He says, in a brief report on the investigations of pellagra: "The many analogies existing between the epidemiology of pellagra and

4. Insects Affecting Domestic Animals, U. S. Dept. Agr., Div. of Ent. Bul., No. 5, n. s., p. 40.

that the best-known insect-borne diseases; the constant association of the disease with *Simulium*-infested streams; the absence of any other arthropod with similar distribution that might account for it; the striking correlation between the fly and the disease in wide geographical distribution, peculiar topographical exigencies, are all facts which strongly point to *Simulium* as the necessary carriers of pellagra."[5]

Further elucidation of this theory is reviewed by Prof. S. J. Hunter in a paper, The Sand Fly and Pellagra, presented before the Entomological Branch of the American Association for Advancement of Science, Washington, D. C., December 27, 1911, and published in The Journal of the American Medical Association, February 24, 1912, vol. 8, pp. 547-548. A part of this review is as follows:

"A. The endemic centers of pellagra in Italy have remained the same since the disease was first described."

"B. The season of the recurrence of pellagra coincides with the season of the appearance of the full-fledged sand fly, even to the extent that if the spring is early or late, the sand fly is early or late in appearing, and pellagra cases are correspondingly early or late in their appearance."

"C. In centers of pellagra infection whole families are attacked at times simultaneously."

"D. In nonpellagrous districts the disease never spreads to others with the advent of a pellagrin from a pellagrous district."

"E. In the case of a family which has removed from a pellagrous to a nonpellagrous district, the children born in the former district are pellagrins, while the children born subsequent to removal to a nonpellagrous district do not develop the disease."

"F. The disease is not hereditary, although infants a few months old may become infected, especially if taken to the fields in pellagrous districts, where their mothers work during the season when sand flies are in evidence."

"G. Pellagra is not contagious, but is transmitted to each individual by an infected sand fly."

Doctor Sambon found three species of *Simulium* in Italy, *S. reptans*, *S. ornatum*, and *S. pubescens*, chiefly the last. In the United States *S. reptans* has not been discovered, but the Kansas State Board of Health, through the State University and its department of entomology, has carried on investigations as to the presence of *Simulium* flies in localities where pellagrins live, and with the most common species, *S. vittatum*,

5. L. W. Sambon (Journ. Trop. Med. and Hyg., London, 13, 1910, Nos. 18, pp. 271-282, 19, pp. 287-300; 20, pp. 305-315; 21, pp. 319-321). Progress report of the investigation of pellagra, as given in U. S. Dept. Agri. Experiment Station Record, vol. 26, abstract No. 8.

has made experiments to transmit pellagra to a monkey, by first letting the flies bite a pellagrin and then bite a monkey. The full significance of the relation of *Simulium* to the transmission of pellagra has not yet been determined.

MOUTH PARTS OF SIMULIUM VITTATUM.

The question of determining the mouth parts of *S. vittatum* I have attempted to answer, both by their location or place of attachment and by their function as given for the mouth parts of insects in general, and especially those of Diptera, by Dimmock, Kræpelin, Packard, Meinert, and J. H. Smith.

Mandibles.

Packard says: "Mandibles are wanting in the imago male Diptera and the females of all flies except Culicidæ and Tabanidæ."[6]

In "The Skeleton of the Head of Insects," by Comstock and Chujiro Kochi, it says, "To this part," the clypeus, "one condyle (the ventral) of the mandible articulates." Now there is such an attachment as this in *Simulium* mouth parts, as is shown in plate XXXIX, figure 21, plate XLI, figure 28, female, and plate XLI, figure 29, for the male. This forms an exception to Packard's statement quoted above. In *Simulium* the mandible has a basal piece similar to the stipes of the maxilla. (Pl. XL, fig. 22c.) The serrate edge of the mandible has about thirty-two saw-like teeth on its end and sides.

Labrum and Hypopharynx.

The next part in question is the presence of a labrum. Kræpelin says: "The labrum (oberlippe) appears as the direct continuation forward of the upper anterior margin of the basi-proboscis. It has a groove on its under surface, and is in fact an inverted semicylinder with double walls."[7] Packard quotes Meinert as follows: "The hypopharynx, most generally free, more or less produced, acute anteriorly, forms with the labrum the tube of the pump (antliæ)."[8]

A careful dissection of *S. vittatum* mouth parts shows that the part Smith called rods of the mandibles (pl. XXXIX, fig. 23, *L*, and pl. XLI, fig. 28) is the labrum, and that it is connected at its base with the hypopharynx. Plate XXXIX,

6. Packard, A. S., A Text Book of Entomology, p. 62.

7. Kræpelin's Proboscis of Musca.

8. Packard, A. S., A Text Book of Entomology, p. 78.

figure 23, *AB*, shows its attachment and plate XLI, figure 27, its place of attachment after the labrum has been removed. In making this dissection for plate XLI, figure 28, I was unable to tear the hypopharynx away from the labrum without destroying the composite arrangement of the other parts. To keep the parts intact I turned the hypopharynx under and backward. The end of it shows in the upper part of the figure. The muscular attachments of the labrum are shown in dotted outline in plate XL, figure 14, composite view. Since the appendage which I have called the labrum does unite with the hypopharynx to form the opening of the pharynx, and since Kræpelin states that "the so-called epipharynx has no existence,"[7] and that the labrum has a lower wall which was once deemed a distinct piece, the epipharynx, I am persuaded that this appendage is the labrum. Those two chitinized points that Smith has called mandibles are closely connected to the end of the labrum, but not muscularly attached. (Pl. XL, fig. 16.) Their origin is conjectural.

The parts of the labrum *A* and *B*, plate XL, figure 24, are attached at their bases to the base of the hypopharynx at A′ and B′, plate XL, figure 24. That part of the labrum *C*, plate XL, figure 24, seems to be of a muscular nature, or tendonous. It is firmly attached to the clypeus, so firmly, in fact, that I have been unable to tear it loose without tearing to pieces the clypeus. (See plate XL, figure 14.) Furthermore, it seems to be free and unattached except at its ends.

Maxillæ of the "First Maxillæ."

According to Packard, the first maxillæ are inserted in the sides of the head just behind the mandibles and mouth. The three basal pieces supporting the maxillæ, the cardo, stipes, and palpifer, in the order given, may be distinguished as shown in plate XL, figure 17, *cs*, *PF*. "The three distal divisions of the maxillæ are called, respectively, beginning with the innermost, the lacina, galea, and palpifer, the latter being a lobe or segment bearing the palpus."[9]

From our dissections these parts are found to be present in the order given, and bearing a like description of typical segments of the same, except the galea, which is wanting. The lacina is attached inside the palpifer to the stipes. The palpifer bears a palpus and is also connected to the stipes. (Pl. XL, fig. 17, *PE*, *PA*.)

9. Packard, A. S., A Text Book of Ent., pp. 62, 63.

A further description by Packard is as follows: "The lacina is more or less jaw-like and armed on the inner edge with either flexible or stiff bristles, spines or teeth." (Pl. XL, fig. 15.) In *S. vittatum* the lacina is produced into a piercing organ with an arrow-like end, with about 26 barb-like formations turned backward on its upper side, and it appears to have a like set on the lower side. These two piercing organs (the lacinæ and mandibles) together with the nub-like chitinized points on the end of the labrum, are evidently used to scrape and tear away the skin in biting. The reason sand flies or buffalo gnats are so tenacious about holding when they are sucking blood may be due to the barbed ends of the lacina caught in the wound. The palpi are four-jointed, the first joint being irregular in shape but about the same length as the second and third joints. The fourth joint is more slender than the second or third and is about two and one-half times the length of one of them. From plate XLI, figure 28, they can be seen to be sparsely covered with setæ.

"Second Maxillæ," or Labium.

Plate XLI, figure 30, shows the so-called second maxillæ, labium or under lip removed. It will be noticed the palpi are wanting. It shows the other typical divisions of a labium, the mentum, glossa, and paraglossa. The labium in *S. vittatum* serves as a sheath for the other mouth parts. This is shown in plate XLI, figure 26, and plate XL, figure 14, composite. It is situated in front of the gula or gular region and is bounded on each side by the gena. See Packard, A Textbook of Entomology, p. 68.

Clypeus.

Plate XL, figure 14*c*, shows the clypeus of the female *Simulium.* According to Packard, the clypeus "is that part of the head situated in front of the epicranium, and anterior to the eyes, forming the roof of the posterior part of the mouth." This describes the position and location of that part of the head of *Simulium* I have called the clypeus. Plate XLI, figure 29, shows a part of the clypeus of a male *Simulium vittatum.* It is smaller and less developed, as are all the mouth parts of the males in comparison to those of the females. Plate XL, figures 20, *c*, 21, and plate XLI, figure 28, show the torn clypeus of the female.

After arriving at the above conclusions in naming the mouth parts of *S. vittatum* my attention was called to a paper by W. Wesche,[10] which describes and figures the mouth parts of *S. reptans* L. The parts he has figured in plate IV of his paper are the maxilla with its palpus and palpifer, the mandible, the labrum with its two minute teeth, the hypopharynx, and the labium. He classes Simulidæ in a group of Diptera in which all mouth parts are distinguishable except the labial palpi, which are aborted. I felt very much gratified at finding his paper to corroborate my conclusions.

The descriptions of the female and male of *Simulium vittatum*, the list of North American species of the family Simuliidæ, and the key to the species of *Simulium* larvæ, pupæ and imagines given below are taken from O. A. Johannsen's work in the New York State Museum Bulletin 68, Aquatic Insects in New York State.

S. vittatum Zetterstedt.

Ins. Lapponica (1844), p. 803.

(*S. tribulatum* Lugger.)

According to Coquillett, *decorum* Walk. (1848) and *argus* Will. (1893) are synonyms.

FEMALE. Gray; nearly bare; dorsum of thorax with five black stripes, the median one entire, the intermediate pairs interrupted, the exterior pair spot-like. Each segment of the abdomen with a dorsal stripe and basally on each side with a black spot, the penultimate segment black. Wings whitish hyaline; halteres white; legs fuscous black, the front side of anterior tibiæ, the base of the middle and hind tibiæ, and the base of the middle and hind metatarsi white. Length 3 mm. Zetterstedt.

FEMALE. The abdomen grey, bases of segments 3 to 7 or 8 marked with a velvet-black fascia produced backward in the middle and at the ends. Length 2 to 4 mm. New York, Minnesota, Nebraska, Kansas, California.

MALE. Hind tarsi bicolorous, mesonotum gray on sides and hind margin, center largely velvet black; without gray streak extending inward from humerus; sides of the abdominal segments 4 to 7 with silvery white hairs. Coquillett.[11]

The markings of the female of this species seem somewhat variable. The thoracic markings are usually quite distinct. The median stripe is nearly of uniform width excepting at the posterior end, where it becomes narrower; the intermediate stripes are f-shaped, the extremities larger, the intermediate

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10. Wesche, W., The Mouth Parts of the Nemocera and their Relation to the other Families in Diptera; Journal of the Royal Microscopical Society, pp. 28-47, 1904, published in London.

11. Bul. 10, n. s. 1898, p. 63.

portion usually a hair line, sometimes obsolete; the exterior pair usually elongated spots. The abdominal markings are as described by Coquillett, though occasionally there are additional disconnected, velvet-black lateral spots, one on each side on segments 3, 4, and 7, and a pair on 5 and 6. Sometimes, also, owing either to the contracted condition of the abdomen or to the fasciæ being narrow, only the black projections of the fasciæ are visible on the more posterior segments, giving the appearance of three spots on each. The legs are often gray; the femora and tibiæ paler at the base, the tibiæ black at tip, the tarsi deep black except basal portion of middle and hind metatarsi. Fore tibiæ with one spur, middle and hind with a pair. Tarsal claws of female simple.

Some specimens from Brookings, S. D., received from Professor Aldrich, and which are the males of *vittatum*, possess the following characters:

MALE: Velvety black, antennæ and palpi dark brown; dorsum of thorax velvety black with the anterior and lateral margins narrowly, and posterior margins in front of scutellum widely silvery gray; also two narrow longitudial gray stripes on dorsum. Or the dorsum might have been described as silvery gray with three very wide velvety-black longitudinal stripes, abbreviated behind. Pleura black, bare; scutellum velvety black; metanotum silvery gray; abdomen velvet-black, the sides of first two or three segments of the ventral surface with a silvery reflection in some lights; legs black, the tips of the fore femora, the basal half of fore and hind tibiæ (sometimes the middle one also), the basal two-thirds of hind metatarsi, and the extreme base of the second hind tarsal joint, yellow. Fore tibiæ with a single spur, middle and hind tibiæ with each two; tarsal claws tridentate. Halteres bright orange-yellow. Wings hyaline, the vein yellow. Length 3 mm.

In an article by Lugger, it is stated that in *S. tribulatum* the male is much smaller than the female, having very large, brilliant, red eyes that meet on top of the head; the body is velvety black with bright golden-yellow and blue spots; the female is gray with black markings. This species is said to be the most abundant in Minnesota, where it is called the "black fly." No further description is given; the figures of the male and female agree with the description of *S. vittatum*. Some specimens sent by Mr. Washburn of the Minnesota Experiment Station, labeled *S. tribulatum*, which were sent to me by Professor Needham, he having obtained them from Mr. J. C. Bradley, of Philadelphia:

LARVA (of *S. vittatum*). Somewhat mottled gray, the side of each segment blackish. The larvæ and pupæ were collected by Mr. J. C.

Bradley, Philadelphia, 1901. The head is of the usual reddish-brown color; the pale yellow antennæ long and cylindric, the second joint about one-third the length the first; the third is a pointed process at the tip of the second. The fans have about forty rays, the cilia being relatively minute. The mandibles are provided with three large apical teeth besides the row of secondary ones; the apical pair of bristles are present. The maxillary palpus has a few spines, and a tuft of a few spines on the basal joint. Hypopharynx and labrum apparently like those of other species. The labium has an elongated middle tooth, those at the end nearly as long, the intermediate ones short (pl. 35, fig. 2), and there are six bristles in each of the two longitudinal rows on the ventral surface. The three blood gills at caudal end are unbranched.

PUPA. The thoracic respiratory filaments each consist of a single main trunk, from which arise eight branches, each of which divides into two, thus making sixteen twigs in all (pl. 35, fig. 1). Near the basal margin of the last two abdominal segments are a few caudal-projecting dorsal hooks and on the tip of the last segment is a pair of blunt spines. The pupal case is of the wall-pocket type, from which the respiratory filaments of the pupa project. Judging from the number of respiratory filaments of the pupa, the species described by Osten Sacken in American Entomologist, volume 2, seems to belong here.

LIST OF THE NORTH AMERICAN SPECIES OF SIMULIIDÆ, GENUS SIMULIUM.

Latreille, Hist. Nat. Crust. Ins. (1804), 14:294.

*argus Williston, N. Am. Fauna. No. 7, May, 1893, p. 253. Cal. (Syn. of *S. vittatum* Zett., according to Coquillett, Harriman Exp. 1900, p. 393.)

argyropeza. See *reptans.*

**bracteatum* Coquillett, U. S. Dept. Agri. Div. Ent. Bul. 10, n. s. 1898, p. 69. Mass., Cal., N. Y., Kan., Mich.

calceatum Harris. A catalogue name, according to Riley, Am. Ent. 1870, p. 467.

cincta. See *reptans.*

**cinereum* Bellardi, Saggio di ditterologia Messicana, 1:13. Cal. (Townsend, Baja, etc., 1893), Mex. (Bellardi).

columbachensis Fabricius nec. Schönhauer. See *reptans.*

decorum Walker. List of Dipterous Insects, etc., ptl., 1848, p. 112. Hudson Bay Ter. (Syn. of *S. vittatum* Zetterstedt, according to Coquillett, n. s., Bul. 10, 1898, p. 68.)

elegans. See *reptans.*

erythrocephala. See *reptans.*

**fulvum* Coquillett, U. S. Nat. Museum Proc. 1902, 25:96.
1898 *ochraceum* Coq. not Walk. Mont., Id., Col., N. M., Alaska.

**glacum* Coquillett, U. S. Nat. Museum Proc., 1902, 25:97. Missouri.

**griseum* Coquillett, U. S. Dept. Agric. Div. Ent. Bul. 10, n. s. 1898, p. 69. Col.

NOTE.—Those names marked * I consider either a distinct species, or not sufficiently described to warrant placing as the synonym of another.

**hirtipes* Fries, Obs. Entomol. Pars, Monogr. Simuliar, 1824, p. 17, 5. Tfl. 1, f. 1. N. Y., Id., Cal. The following synonymy is according to Schiner:

1830 *rufipes* Meigen, Syst. Beschr., 6:311-17.

1830 *hirtipes* Fries, Meigen, Syst. Bescher, 6:312-18.

1850 *hirtipes* Fries, Zetterstedt, Dipt. Scand., 9:3426-28.

innoxium Comstock. See *S. pictipes* Hagen.

**invenustum* Walker, List of Dipterous Insects, etc., 1848, p. 112. Hudson Bay Ter. (*pecuarum* Riley is a synonym of this, according to Coquillett, 1898).

**irritatum* Lugger. Figured but not described in Univ. Minn. Agric. Sta. Bul. 1896, p. 203.

**meriodionale* Riley, Dept. Agric. An. Rep't for 1886, 1887, p. 512. 1891. *occidentale* Townsend, Psyche, July, 1891, p. 107. Mass., Miss., Neb., Tex. (synonym and localities according to Coquillett, Bull. 10, n. s. 1898). N. J. (Johnson) Kan. and Id.

**metallicum* Bellardi, Saggio di ditterologia Messicana, 1859, 1:14. Mex.

**mexicanum* Bellardi, Saggio di ditterologia Messicana, Appendix 6, 1862. Mex.

minutum Lugger, Minn. Agric. Exp. Sta. Bul. 1896, p. 202. Minn. (Figured but not described.) See *vittatum*.

molestum Harris. See *venustum*.

novicum Harris, Ins. Inj. to Veg. p. 601. This is a *Ceratopogon*.

occidentale Townsend. See *meriodionale*.

**ochraceum* Walker, Ent. Soc. London. Trans. n. s. 3:33. Mex.

**pecuarum* Riley (synonym of *invenustum*, according to Coquillett).

1887 *pecuarum* Riley, U. S. Dept. Agric. Rep't for 1886, p. 512. N. H., N. Y., Mass., Ct., D. C., Mich., Miss., La. (synonym and localities according to Coquillett, U. S. Dept. Agric. Bul. 10, n. s. 1898). N. J. (Johnson).

**pictipes* Hagen, Bost. Soc. Nat. Hist. Proc. 1880, 20:305. N. Y., Tex., Cal. (Coquillett, 1898), Id.

1895 *innoxium* Comstock. Name given in Manual for the Study of Insects.

piscicidium Riley. See *venustum*.

posticata Meigen. See *reptans*.

**pulchrum* Philippi, Chilian Diptera, 1865, p. 633. S. Am. and St. Vincent, W. I.

1896 *tarsale* Williston, Diptera of St. Vincent, W. I., p. 268. Synonymy according to Hunter, Catalogue of S. Am. Diptera. 1900.

**quadrivittatum* Loew, Berl. Ent. Zeit. 1862, Centur. 2, p. 2. Cuba.

**reptans* Linnæus, Fauna Suec. 1893. Europe, Greenland (Lundbeck, 1898) 1761. Synonymy according to Schiner:

1767 *sericea* Linnæus, Syst. Nat., 12:978, 58.

1776 *erythrocephala* DeGeer, Ins., 6:161, 37 (Tipula).

1781 *reptans* L. Schrank, Enum. Ins. Austr., p. 985 (Culex).

1787 *colombatchensis* Fabricius, Mantissa Ins. 2:333 (Rhagio).

1804 *argyropeza* Meigen, Classif., 1:96.

1818 *reptans* Meigen, Syst. Beschr., 1:291-92.
1818 *sericea* Meigen, Syst. Beschr., 1:296-98.
1818 *elegans* Meigen, Syst. Beschr., 1:296-99.
1818 *variegata* Meigen, Syst. Beschr., 1:292-93.
1823 *reptans* Fries, Obs. Entomol. Pars. 1 Monogr. Simuliar, p. 13.
1830 *cincta* Meigen, Syst. Beschr., 6:311, 14.
1838 *posticata* Meigen, Syst. Beschr., 7:52, 21.

rufipes Meigen. See *hirtipes*.

sericea Linnæus. See *reptans*.

**tamaulipense* Townsend, N. Y. Ent. Soc. Jour. 1898, v. 7. Tex.

tarsale Williston. See *pulchrum* Phillipi.

tribulatum Lugger, Minn. Agric. Exp. Sta. Rep't 1896, p. 205-7. Probably equals *vittatum* (p. 385, Seq.) (Figured but not described.)

**venustum* Say, Acad. Nat. Sci. Phil. Jour., 3:28: Compl. Wr. 2:51 Wiedemann, Auss. zw. Ins., 1:71. Ohio, D. C. (Osten Sacken, catalogue), N. J. (Johnson), Can., N. H., N. Y., Mich., Minn., Wyo., B. C., Cal., Tex., La., Miss., Fla. (Coquillett), Id. The following synonymy is according to Coquillett, 1898:

1862 *molestum* Harris, Ins. Inj. to Vegetation. (Not described.)
1870 *piscicidium* Riley, Am. Ent. 2:367. Mumford, N. Y.

**virgatum* Coquillett, U. S. Nat. Mus. Proc. 1902, 25:97. N. M.

**vittatum* Zetterstedt, Ins. Lapponica. 1840. p. 803.

stæger Grœnl. Antl. Greenland (Osten Sacken's catalogue), N. J. (Johnson), Alas. (Coquillett 1900), Cal., Kan., Minn., N. Y., Neb. (Coquillett 1898), Id., S. Dak. The following synonymy according to Coquillett:

1848 *decorum* Walker, List. Ins. p. 112. Hudson Bay Ter.
1893 *argus* Williston, N. Am. Fauna, No. 7, p. 253. Cal.

KEY TO SPECIES OF SIMULIUM.

Larvæ.

1\. Mature larva of 6 or 7 mm. long, with the dorsal surface of the head nearly white; the rays of the fan number about 30. Larva from Santa Cruz mountains, Cal. (p. 387).
Head usually brown; rays of the fan usually 40 or more 2

2\. The top of the head with six black blotches or spots. Larvæ from New Mexico (p. 386).
Head without six dark spots 3

3\. The Caudal blood gills are three simple papillæ 4
The three main branches are again subdivided 6

4\. The middle tooth of the labium is simple and pointed, labium with six pairs of setæ on its ventral surface (pl. 35, fig. 8).
Pecuarum (*-invenustum*)

6\. Full-grown larvæ 10-12 mm. in length, black in color, its labium with an elongate middle tooth (pl. 36, fig. 3) .... *pictipes*
Paler larvæ less than 10 mm. in length 7

7. No setæ on the last joint of the maxillary palpus, middle tooth of the labium longer than the two lateral ones, four pairs of setæ on its ventral surface. The pair of apical setæ of the mandible not differentiated from the hairs which overhang the apex. *meribionale*
   Mandible with a pair of apical bristles, palpus of the maxilla with setæ 8
8. Middle tooth of the labium enlarged, ventral surface of labium with five pairs of setæ (pl. 37, fig. 6) ....*venustum*
   Middle tooth not enlarged (varieties of *venustum*) 9
9. Labium with four pairs of ventral setæ (pl. 37, fig. 14) ....var. *a*
   With seven pairs of setæ (fig. 5) ....var. *piscicidium*

PUPÆ.

(Arranged according to the number of filaments in each respiratory tuft.)

1. With six filaments:
   a. Legs in their cases appear bicolored * ....*venustum*
   b. Legs unicolored ....*meridionale*
2. With eight filaments:
   a. Pupa 4.5 mm. long; Arizona species. Pupa described in Am. Ent. Soc. Trans., p. 45; 1893.
   b. Less than 4 mm. long; eastern species. *venustum*, var. *piscicidium*
3. With nine filaments. Pupal case like that on plate 35, figure 5. *pictipes*
4. With ten filaments ....var *a* of *venustum*
5. With twelve filaments. Pupal case (pl. 35, fig. 5). From Santa Cruz mountains, California (p. 387).
6. With sixteen filaments ....*vittatum*
7. With twenty-four to forty-eight filaments (pl. 33, fig. 10). *pecuarum*
8. With sixty or more filaments ....*hirtipes*

IMAGINES.

1. Ground color of the thorax and abdomen deep yellow 2
   Gray or black; its hairs may be pale 3
2. "Femora with black tip, length of fly 2 mm." Mexico...*ochraceum*
   "Femora with black tips. Length 3 to 4.5 mm. Rocky Mountains." *fulvum*
3. Hind tarsi with its basal joint partly yellow; legs bicolored 9
   Hind tarsi unicolored † 4
4. Halteres dusky; thorax not striped 5
   Halteres white or yellow; the female with striped thorax and bifid tarsal claws 6

* In order to see this it will be necessary to examine nearly mature specimens, and perhaps to draw them from their pupal skins.

† The male of the *pictipes* sometimes has legs nearly unicolored; it is, however, included in the preceding section.

5. Body black; the female with dense yellow pile, her tarsal claws simple; the male with dense hair on the legs, his tarsal claws trifid. The wing with its radius three branched. Length 3 to 4.5 mm. .... *hirtipes*
"Body gray, legs reddish gray, feet black; length 3 mm." This is said by Mr. Coquillet to be the same as *pecuarum* Riley. *invenustum*
6. Males, eyes contiguous 7
Females, eyes separated by a distinct line 8
7. Thorax velvety black; legs reddish with black tarsi. Length 1.5 to 2 mm. Compare here also *bracteatum* (male), "with legs wholly brown" .... *meridionale*
Thorax brownish black; legs usually pale; tip of tarsi not black. Length from 2 to 4 mm. .... *pecuarum*
8. Thorax with silvery-white pubesence; legs brownish black, covered with whitish hairs. A small variety (less than 2 mm. long) from New Mexico has been named *occidentale* Town. (q. v.) *meriodionale*
Thorax with yellow hairs; legs reddish brown, covered with yellow hairs; tip of tarsi blackish .... *pecuarum*
9. Male, eyes contiguous...10
Females, eyes separated 20
10. "Mesonotum wholly velvet black; gray spot on sides of the second, fifth, sixth, and seventh segments of abdomen. Length 1.5 mm." *bracteatum*
Metanotum striped, or with grayish or metallic reflections 11
11. Dorsum of thorax with one or more longitudinal stripes 12
Dorsum unstriped 14
12. Thorax with four longitudinal stripes; posterior margin white; abdomen black. Sex not given. Cuban species..*quadrivittatum*
Thorax not so marked 13
13. Front and middle femora and tibiæ wholly yellow; center of mesonotum with a black vitta, elsewhere gray. Length 1.5 mm. Colorado species .... *griseum*
Femora and tibiæ wholly or partly brown 13*a*
13*a*. "Femora and front tibæ yellow, their apices brown, middle tibiæ brown, a yellow ring beyond the base, hind tibiæ brown, the extreme base yellowish. Mesonotum marked with a narrow median and laterally with a very broad velvet-black fascia." Length 3 mm. New Mexico .... *virgatum*
Front femora brown, tibiæ brown on apical part 13*b*
13*b*. Mesonotum with two narrow gray stripes (sometimes quite indistinct) on a velvet-black ground, in which there are scattered golden hairs .... *vittatum*
"Mesonotum marked with a narrow median and slightly wider lateral black vittæ." Length 2.5 mm. Missouri........*glaucum*
14. Anterior femora yellow. Mexican species 15
Anterior femora black 17

15. Abdomen with the base of the second segment and the sides of the third, fourth, and fifth yellowish white; tibiæ fuscous black with yellow bases. Length 4 mm. .... *mexicanum*
Abdomen black 16
16. Metallic bluish black species; middle portion of fore tibiæ, base of middle and hind tibiæ, base of first and second joints of middle and hind tarsi, whitish. Length 2 mm. .... *metallicum*
Thorax fuscous and cinereous pollinose; the humeri pallid, fore coxæ pale, middle and hind ones dark; femora pale at the base, black at the tip; tibiæ black. Length 3 mm. .... *cinereum*
17. An oblique metallic streak extending inward from each humerus; posterior part of the thorax metallic. Length 2 to 2.5 mm. *venustum*
Humeral spots not metallic 18
18. Anterior coxæ yellow; long hair on femora and hind tibiæ; thorax velvet black with white pruinose margin (Greenland) ..*reptans*
Anterior coxæ black 19
19. Thorax velvet black, with oblique cinereous humeral spots, and usually two tiny metallic spots between them. Length 3 to 4 mm. *pictipes*
Thorax velvety black with two very narrow gray stripes and posterior margin; hind tibiæ usually yellow at the base, hair on legs sparse .... *vittatum*
20. Thorax striped 21
Thorax without stripes 25
21. Dorsum of thorax with four longitudinal lines, posterior margin, white pollinose; abdomen opaque black. Cuban species. *quadrivittatum*
Not with four stripes 22
22. Dorsum of the thorax with five stripes. the outer ones spot-like, the intermediate ones clubbed at the ends; abdomen with black fascia on each segment, produced posteriorly at the middle and the ends. Sometimes the last few segments have only three or five spots .... *vittatum*
Toe with one or three stripes 23
23. With three stripes 24
"With an indication of a darker median vitta" (see 31) ..*griseum*
24. Small species, length about 1.5 mm. "Abdomen silvery, third and fourth segments wholly brownish, sometimes with a median spot on each; legs yellowish, tarsi blackish or brownish." Species from Texas .... *tamaulipense*
Larger species 3 mm. or more in length 24*a*
24*a*. Middle tibiæ brown with a yellow ring around the base; vittæ of mesonotum brownish, the median vitta dilated posteriorly, wider than either of the lateral ones. New Mexico .... *virgatum*
Femora and tibiæ grayish, sometimes quite pale, tips of tibiæ black. Laterdorsal thoracic stripes clubbed at the anterior end. Third, fourth, fifth, and part of the sixth and seventh abdominal segments with velvet-black fasciæ; center of 6, 7, 8, grayish or dull brown .... *pictipes*

25. Abdomen without distinct black spots 26
Abdomen spotted 31
26. Abdomen black, covered with long yellow pile, legs yellow, the tips of the femora and tibiæ, and all the tarsi except basal two-thirds of the hind metatarsi, brown .... *bracteatum*
Abdomen nearly bare 27
27. Body gray or cinereous 28
Body brown or black 29
28. "Body gray with a milky white lustre, specially the pleura and pectus. Legs tawny, femora and tibiæ with irregular piceous bands, tarsi piceous. Length 2.5 mm. Hudson Bay Ter." This is a synonym of *vittatum* Zett., according to Mr. Coquillet (1898). *decorum*
Thorax fuscous or cinereous pollinose, humeri pallid, pleura pale cinereous, scutellum pale at the tip; abdomen blackish; fore coxæ pale, middle and hind ones cinereous; femora pale at the base, black at the tip, tibiæ black. Length 3 mm. Mexican species .... *cinereum*
29. Abdomen somewhat shinning, yellowish gray or whitish at the sides, and yellow at the base; legs brown, tibiæ and fore coxæ white, tip of tibiæ and all tarsi black. European species, also occurring in Greenland .... *reptans*
Basal segments of abdomen opaque, distal four segments somewhat shining black or brown. Two long hairs at the tip of the first and third fore tarsal joints 30
30. Legs reddish yellow, tarsi black, except proximal half of middle and hind metatarsi which are light yellow. Length 2 mm. (St. Vincent Island.) This is a synonym of *pulchrum* Phil., according to Hunter .... *tarsale*
Legs black; base of tibiæ, first joint of middle and hind tarsi and sometimes base of femora yellow; extensor surface of all the tibiæ more or less whitish. A widely distributed and variable species .... *venustum*
31. Length 1.5 mm. Front and middle femora and tibiæ wholly yellow; hind ones, except apices, also yellow. (Colorado) ...... *griseum*
Length 2.5 mm. Legs, brownish black, distal part of femora, base of tibia, and greater part of metatarsi light yellow (California). *argus*

Some of the characters used in this table have been taken from the key given in the United States Department of Agriculture, Division of Entomology, Bulletin 10, new series, 1898, page 68, by Mr. Coquillet. In the table given above I have included all the North American species. For the southwestern and Mexican species it should, however, be used with caution, as I did not have specimens of some of these.

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Anatomy of *Simulium vittatum.*

BY H. B. HUNGERFORD.

(Submitted in partial fulfillment of the requirements for the degree of master of arts.)

Plates XLIII-XLV.

ACKNOWLEDGMENTS.

THE preparation of this paper was undertaken in connection with the experimental work upon the sand fly and pellagra being carried on by Professor Hunter of the University of Kansas.

The anatomical studies were taken up at the suggestion of Professor Hunter, and the writer desires herewith to express his appreciation to him for his kindly interest and helpful suggestions during the progress of the work.

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ANATOMY OF *SIMULIUM VITTATUM.*

INTRODUCTION.

The recent widespread interest in the sand fly as the possible carrier of the disease "pellagra" has given the writer a desire to know something of the anatomy and histology of the form common in Kansas, namely *Simulium vittatum.*

The study of the gross structures of *Simulium* has been of some scientific interest aside from its possible connection with pellagra, for, so far as the writer has been able to find, no

morphological study of the adult has been made with the exception of one paper by F. H. Taylor, 1902, on the "Tracheal System of *Simulium*," and studies of the mouth structures by Smith, Meinert and MacCloskie.

A number of writers have studied the larvæ and pupæ in connection with some general problems dealing with a group of related forms. Thus Osten Sachen, '70, made a study of the transformations of *Simulium* species, and Packard, '72, in his "Embryological Studies on Hexapodous Insects" studied the development of *Simulium*. Kellogg and Vaney (1901) used the *Simulium* along with Chironomids and like forms in their study of "Phagocytosis in the Postembryonic Development of Diptera." Vaney (1902) continuing his studies of the fat bodies examined sand flies and other inferior Diptera as he calls them (Culex, Chironomids, etc.). Weismann in studying imaginal buds referred to *S. sericea,* and Miall (1900) in his researches on the respiratory appendages of pupæ figures a *Simulium* sp. Headlee, '06, made a study of the blood gills of the larva of *S. pictipes,* and Dutt in an unpublished article at Cornell recorded his work upon the silk glands of *Simulium* larvæ. So scattered and fragmentary has been the morphological work upon this important insect pest that it has been the desire of the writer to make a careful study of this form in all its stages. However, it is the purpose of this paper to present but briefly the more salient facts regarding the anatomy of the adult female fly.

TAXONOMIC POSITION AND DESCRIPTION OF FORM STUDIED.

Simulium vittatum is a small, compactly built fly belonging to the family "Simuliidæ."

The Simuliidæ are known in the vernacular as "turkey gnats," "buffalo gnats," "black flies," and "sand flies." They are related in a general way to the mosquitoes, crane flies, fungus gnats, and punkies, but may be readily distinguished from them by their general stoutness of body and broadness of wing. The legs of the mosquitoes and of most gnats are long and rather slender, but those of the sand flies are short and stout. Their general form is so characteristic that they are easily recognized. They possess very broad wings. Their bodies are short and the thorax so much arched that they appear, as Johannsen expresses it "humpbacked." (See Fig. 1, Plate XLIII.)

Technically the adults of this family are distinguished by the following characteristics:

Antennæ are but little longer than the head, flattened or cylindrical, 10-jointed; the two basal joints differentiated, the others closely united and never plumose.

The eyes are round or reniform and holoptic in the male; ocelli absent.

Proboscis is not elongated, possessing small horny labella and four-jointed palps. The first joint of the palp is short, the two following of equal length, and the last one longer and more slender than the preceding.

The thorax is arched, without a suture, and the scutellum small.

The abdomen is cylindrical, made up of 7 or 8 (or more) segments, and the genitalia are concealed.

The legs are strong and not elongate, the femora broad and flat, tibia usually with terminal spurs; first joint of tarsi longer than the following and usually dilated in the male, the last joint small; wings large and broad, with distinct alulæ, anterior veins thickened, the others slender, auxiliary vein terminating in the costa about the middle of the wing which is not continuous beyond the tip of the wing. (See Fig. 1, Plate XLIII.) Second longitudinal vein wanting, the first and third lying close to each other, the third arising from the first rectangularly before the end of the auxiliary vein; anterior cross vein very short, fourth vein curved, forked nearly opposite the anterior cross vein, the forks terminating near the tip of the wing. (See Fig. 1, Plate XLIII.)

Similium vittatum—Zetterstedt.*

(*Tribulatum* Lugger, *Decorum* (Walk), *argus* (Will).

ADULT—FEMALE. Gray, nearly bare; dorsum of thorax with five black stripes, the median one entire, the intermediate pairs interrupted, the exterior pair spotlike. Each segment of the abdomen with a black dorsal stripe, and basally on each side with a black spot, the penultimate segment black.

Wings whitish hyaline; halteres white; legs fuscous black; the front side of the anterior tibiæ, the base of the middle and hind tibiæ, and the base of the middle and hind metatarsi white; length 3 mm. (Zetterstedt.)

* Johannsen.

Coquillett adds the following: "FEMALE. Abdomen gray, bases of segments 3 to 7 or 8 marked with a velvet-black fascia produced backward in the middle and at the ends, length 2 to 4 mm. Found in New York, Minnesota, Kansas, Illinois, and California."

MALE. Hind tarsi bicolorous, mesonotum gray on sides and hind margin, center largely velvet-black without gray streak extending inward from humerus, sides of abdominal segments 4 to 7 with silvery white hairs. (Coquillett.) To this Johannsen adds: "The markings of the female of this species seem somewhat variable, the thoracic markings are usually quite distinct, the median stripe is nearly of uniform width excepting at the posterior end where it becomes narrower; the intermediate stripes are ʃ shaped, the extremities larger, the intermediate portion usually a hair line, sometimes obsolete, the exterior pair usually elongated spots. The abdominal markings are as described by Coquillett, though occasionally there are additional disconnected, velvet-black lateral spots, one on each side on segments 3, 4 and 7, and a pair on 5 and 6. Sometimes, also, owing either to the contracted condition of the abdomen or to the fasciæ being narrow, only the black projections of the fasciæ are visible on the more posterior segments, giving the appearance of three spots on each. The legs are often gray, the femoræ and tibiæ paler at the base, the tibiæ black at tip, the tarsi deep black except basal portion of middle and hind metatarsi, fore tibiæ with one spur, middle and hind with one pair. Tarsal claws of female simple.

LARVÆ. Caudal blood gills, 3 simple papillæ; the middle tooth of the labium simple and pointed, labium with six pairs of setæ on its ventral surface; somewhat mottled gray, the sides of each segment blackish; the head is of the usual reddish-brown color, the pale yellow antennæ long and cylindrical, the second joint about one-third of the length of the first; the third is a pointed process at the tip of the second. The fans have about 40 rays, the cilia being relatively minute; the mandibles are provided with three large apical teeth besides the row of secondary ones; the apical pair of bristles is present; the maxillary palpus has a few spines, and a tuft of a few spines on the basal joint; hypopharynx and labrum apparently like those of other species; the labrum has an elongate middle tooth, those at the end nearly as long, the intermediate ones short and there are six bristles in each of the

two longitudinal rows on the ventral surface; the three blood gills at caudal end, unbranched.

PUPA. The thoracic respiratory filaments each consist of a single main trunk, from which arise eight branches, each of which divides into two, thus making 16 twigs in all. Near the basal margin of the last few abdominal segments are a few caudal-projecting dorsal hooks, and on the tip of the last segment is a pair of blunt spines. The pupal case is of the wall-pocket type, from which the respiratory filaments of the pupa project.

GENERAL HABITS AND LIFE HISTORY OF THE FAMILY.

The habits of the adults are quite generally known because in many places they are fully as troublesome as mosquitoes. They are so-called "bloodsuckers," feeding upon the blood of horses, cattle, and man, sometimes to such an extent as to be of considerable economic importance. (See Riley in N. Y. State Mus. Bull. No. 68.) They lay their eggs on the surface of rocks over which shallow water is flowing rapidly, as on the rocks of shallow rapids and the ledges of waterfalls. Their eggs are laid in masses one layer deep. In about eight or ten days they hatch into larvæ which attach themselves by their caudal end to the rocks or stems of aquatic plants.

The larvæ retain their position in the swiftest current by means of a disc-like sucker on the posterior end of the body. When they desire to move to a new location they may do so by anchoring a silken thread to the support and, releasing their hold, spinning out their silk as they are washed downstream, but retaining control of it very much after the fashion of spiders suspending themselves in mid-air, or they may travel over the surface of the rocks with a looping gait similar to that of a measuring worm.

They are said to feed upon algæ, diatoms, and parts of phaneragamous plants.* In those I have examined diatoms have comprised most of the material found in the digestive cannal.

When the larva is ready to transform it spins a tough pupal case firmly attached to the rock and changes to a strangely shaped pupa. Then in due time the fly comes from the pupal skin, rises to the surface of the water and shortly takes flight.

* Miss R. Phillips, 1890, of Cornell University, reports that among the algæ taken by the larvæ are Nothix, Cladophora, and Vauchera. Walter T. Emery adds Conferva, Scenedesmus, Chlamydomonas, Euglena.

Mr. Emery in his paper on the "Morphology and Biology of *Simulium vittatum*" gives some interesting data regarding the biology of this insect, to which the reader is referred.

TECHNIQUE FOR THE STUDY OF GROSS ANATOMY.

Most of the studies of the gross anatomy of the *Simulium* fly were made by means of free dissections under the binocular.* Quite a number of the body tissues of the fly are transparent, and for a study of these the direct sunlight gave the best illumination. A spot light made by focusing sunlight through a reading glass gave excellent illumination. These studies were verified by serial microtome sections.

The comparatively small size of the fly (3 mm.) necessitated the use of a technique somewhat more delicate than is usually necessary, and inasmuch as the majority of students of small forms have failed to record their methods of study, I have felt it desirable to give a brief account of the technique used in these studies.

The needles used in the dissection work were made by placing the base of minuten nadeln points (used in mounting small insects) in handles of wood and grinding the points on emery paper until they were small enough for use.

The flies were held in any given position by paraffin. To do this, some paraffin was placed in a small shallow porcelain staining dish, and warmed to melting point. The fly was then placed about half its width in the paraffin in the desired position and the paraffin cooled.

The dish was then filled with either normal salt solution or with 50 per cent alcohol, depending upon whether the material was fresh or fixed. With careful work and a steady hand one could determine the various systems with considerable accuracy. One fly would usually serve for several days' dissection study, and by covering the dish with a lid and inverting a tumbler over all to prevent evaporation of the alcohol the specimen would be ready for further study without the usual delay.

Most of the dissections were made with the fly on its side. The large muscles of the thorax and the deep incision of the exoskeleton between the thorax and the abdomen made dorsal dissections quite unsatisfactory. Ventral dissections were

* I used a Zeiss machine and found that the No. 2 and No. 4 eye pieces used with the A2 objective gave by far the most satisfactory results for the study of general anatomy.

used only to verify the other studies by giving a different point of view.

SECTIONAL STUDY.

Killing and Fixing. In order to determine the best method of fixing and staining the adult flies it was necessary to try a number of fixations and stains.

The flies were divided into lots and killed and fixed in the following ways:

Six lots were treated with picro-aceto-sublimate for 12, 18, and 24 hours respectively. When they had been in the fluid the specified length of time, the liquid was carefully drawn off with a pipette, and the vials filled with 70 per cent grain alcohol. At the end of 24 hours the alcohol was changed by the pipette method as above, and this process of changing the alcohol repeated for 3 days. At the end of that time the 70 per cent was replaced with 85 per cent alcohol and the lots stored.

Six lots were captured and placed in picro-formal for 12 hours, 18 hours, and until they sank, respectively. They were then washed out with 70 per cent alcohol as for the picro-aceto-sublimate and stored in 85 per cent alcohol.

Two lots were fixed in Fleming's stronger mixture. The flies were allowed to remain in the fixing fluid until they sank. Then they were changed to water and washed for three days. From the water they were transferred to 95 per cent alcohol.

Six lots of live sand flies were fixed in Gilson's chloro-aceto-sublimate for 10 minutes, 20 minutes, and until they sank. They were then washed in 70 per cent alcohol for several days and stored in 85 per cent alcohol.

Six lots were fixed in Zenker's fluid for 6 hours, 12 hours, and until they sank, respectively. They were then washed out in water and transferred to alcohol containing tincture of iodine.

In the above series the chloro-aceto-sublimate gave the best fixation.

C. G. Hewett, '07, in his work with the house fly used Henning's solution made up as follows: Nitric acid 16 parts, chromic acid (.5 per cent) 16 parts, picric acid saturated in water 12 parts, and absolute alcohol 42 parts. After fixing the material he washed out in iodine water. This method he finds not only fixes but to a certain extent softens the chitin,

which facilitates sectioning, providing the material is not allowed to be imbedded too long.

Hot alcohol and hot Gilson's both give very good results for larval forms, as has been noted by Headlee, '06, in his work on *Simulium* blood gills.

Specimens killed in hot Perenyi's fluid, cut and removed to fresh fluid for six hours and then transferred to 70 per cent alcohol, were well fixed.

But the best fixation that I have tried was obtained by the use of Kable's Fixation. This was recommended to me by Dr. Brues, of Harvard, who used it as a fixation for the *Stomoxys calcitrans*. It is made up as follows: 30 parts water, 15 parts normal 95 per cent alcohol, 6 parts formaline (40 per cent), 1 part of glacial acetic acid. The flies are killed in this hot solution and transferred when cold to 70 per cent alcohol.

Since the Gilson's mixture mentioned above gave very satisfactory results it might also be well to give directions for making it. To make up a two-liter bottleful use:

30 cc. of 80 per cent nitric acid.
8 cc. of glacial acetic acid.
40 grs. corrosive sublimate.
200 cc. of 60 per cent alcohol.
1760 cc. of distilled water.

Infiltrating and Imbedding. When the specimens were desired for study, they were graded up from the 85 per cent alcohol to absolute alcohol in small glass dishes covered with ground glass covers. If they were stored in 85 per cent alcohol they were slipped up to 95 per cent and left for 48 hours to harden. Then from this they were transferred to absolute and left for a like time. From this they were transferred to a vial which had been half filled with xylol and then filled with absolute alcohol. Here they were left for 24 hours, after which they were returned to a glass dish of pure xylol. The dish was then placed on the top shelf of an electric drying oven, and a few flakes of paraffin dropped into it. When dissolved more were added and the dish placed nearer the heat. Bits of paraffin were added from time to time for the following six hours. By the end of that time the flies could be transferred to pure melted paraffin and left there for 24 hours or longer.

Cutting and Mounting. When the flies were infiltrated they were imbedded and cut in serial sections of from 4 to 15 microns in thickness.

The dry paraffin ribbons were placed on an absolutely clean slide and floated with prepared egg albumen. The albumen was then drained off and the slide held just enough below the surface of tepid distilled water to float out the folds and allow the ribbons to be arranged. The slides were then air-dried for one week, after which they were warmed enough to melt down the paraffin and placed in xylol for ten minutes. From the xylol they were passed down through the alcohols to the grade used in the stain.

Staining. Five stains were used in the studies made with the *Simulium* fly.

I. For thin sections to be studied for parasitic forms *Gemsa's Lasung* was used. This stain was diluted 1 drop to 1 cc. of water made faintly alkaline with weak potassium carbonate (1%). The sections were stained with this for fifteen minutes. (With this stain chromatin is stained blue and protozoa and bacteria pinkish.) Differentiation was made with tap water. After dehydrating in the alcohols they were transferred to xylol and from the xylol to the balsam mount.

II. For ordinary work the sections of any thickness were run down to 50% alcohol and stained for twelve hours in borax carmine, differentiated in acid alcohol, dehydrated and mounted as above.

III. Iron hæmatoxylin was used in the usual way.

IV. Good results were obtained by overstaining with Delafield's hæmatoxylin and differentiating with acid alcohol as suggested by Hewett.

V. The best results were obtained by running the sections down to 25% alcohol and staining in ferric alum for 4 hours, then Hædenhain's hæmatoxylin (5% aq. solution) for 12 hours. Following this they were bleached in ferric alum, placed in orange g. and dipped back and forth in the two stains till proper results were obtained as determined by following the action of the stains under the low-power compound. Then they were rehydrated, passed up through xylol, and mounted.

THE THORAX OF SIMULIUM.

The thorax of dipterous insects always presents a problem. The fact that they possess but one pair of wings has led to the adjusting of the thoracic box to meet these conditions. Thus the mesothoracic division which bears the wings is greatly developed while the prothoracic and metathoracic divisions are reduced. Time has not permitted a detailed report on the homologies of the several sclerites making up the prothorax. Suffice it to say that the prothoracic cylinder is not typical, the sclerites conforming not at all to our conception of the normal arrangement of parts. The mesothorax, on the other hand, is a simpler matter. The notum is large, occupying the whole of the dorsal side of the thorax. It is not transversed by well-marked sutures that could mark the præscutum, scutum, scutellum, and postscutellum. As a whole it is a convex shield. It is this sclerite that gives to *Simulium* its characteristic "humpedback" shape.

Laterally, we have the alar membrane for the wing attachment above and the episternum and epimeron below. The mesosternum is large and well marked. The metathorax bears the haltere and the metathoracic spiracle on its pleural aspects.

WINGS. The two wings are borne at the sides of the scutum of the mesothorax. They are attached, by means of the sclerites at the base of the wings, to the alar membrane. They are broad and characterized by having only the veins of the anterior portion of the wing developed, the other veins showing only as thickened but transparent tracings. (See Fig. 1, Pl. XLIII.) Following the nomenclature of Johannsen for this family I describe the venation of the wing as follows: The anterior edge of the wing is reënforced by the costa which extends to a point some little distance before the tip of the wing. The *subcosta* joins the *costa* at a point about one-third the distance from the base of the wing to the tip. *Radius* is all but fused with *subcosta*, showing up a clear line along the posterior edge of *subcosta* for 3/5 of its length, (subcosta), it then appears as a separate vein. *R.* joins costa a little beyond the point where *subcosta* meets *costa.* This point is marked by a slight emargination in the costal margin of the wing. *R2-3-4-5* extends for a considerable distance, finally meeting *costa* shortly before its termination (costa). The base of *media* is well marked. This well-marked portion ex-

tends for the first 1/6 of the length of the vein. There a cross vein connects *media* with radius and the vein becomes transparent, soon branching into M_1 and M_2, M_1 extending to the tip of the wing and M_2 running out along the posterior side of the wing. *Cubitus* is represented more as a fold than as a vein. There are two clearly marked anal veins, *anal 1* being straight, and *anal 2* curved; the anal area lying posteriorly to the anal veins is creased by two folds.

LEGS. The legs of *Simulium* are stouter than those of most of the related forms. The following segments are present: *Coxa,* a strong cylindrical segment; *trochanter* narrow and somewhat irregular; *femur,* rather stout; *tibia,* about the length of *femur,* also stout; *tarsi,* 5-jointed, joint one about as long as the remaining joints taken together, the last bearing simple claws.

ALIMENTARY CANAL.

The alimentary canal is a comparatively straight tube extending from the buccal cavity to the anal opening in the last segment. (Fig. 2, Pl. XLIII.)

The Proboscis. This is made up by the close application of the hypopharynx to the so-called labrum and ensheathed by the fleshy labium. This strongly chitinized tube (Ph., Fig. 12, Pl. XLV) is well provided with muscular attachments as shown by the projection drawing of a section of the head (Fig. 12, Pl. XLV). At its upper end it meets the œsophagus, which passes back between commissures connecting the brain and subœsophagial ganglion.

It is joined near its base with the duct of the salivary glands by an apparatus shown in Fig. 11, and called by Meinert the "receptaculum" or salivary receptacle (Fig. 11, Pl. XLV).

The Œsophagus. The œsophagus joins the pharynx at right angles, this union being banded by a strongly chitinized collar (Fig. 11, C). It is smaller than the pharyngeal box, and is flanked by chitinized plates from which arise muscles that correspond to Meinert's musculature of Tabanus and have a similar function.

There arises from the dorsal wall of the œsophagus, caudad of the chitinized portion, a muscle that extends upward and backward to take its insertion in the wall of the vertex of the head. The œsophagus narrows as it passes from the head to

the thorax, being at this point little larger than the nerve cord just below it. Upon reaching the thorax it may change its direction slightly and continue its way through the thorax to the abdomen, or it may make a sudden bend dorsally and as abruptly bend back again, then continuing its course from there on as in the other case. In any event the slender portion of the tube suddenly enlarges, forming a tube of three times its diameter, the union of these two parts being marked by an enlargement, or a series of three enlargements. From the ventral side of this enlargement there arises a thin-walled duct (Fig. 11, Pl. XLV) that leads backward beneath the canal and expands into a rather large pouch. This duct can not strictly be defined as such, for it is simply the cephalic end of a sac which gradually narrows till it joins the digestive canal at the point shown in the figure (Fig. 11). The walls of this pouch are extremely thin and transparent when distended and at such times it occupies a considerable space in the abdomen. As shown in fig. 11 Fr. and in fig. 2 Fr. the pouch is somewhat contracted and shows muscle fibres. This sac by virtue of its position and union with the proventriculus leads to the conclusion that it must function as a food reservoir.*

The Stomach. The digestive tract upon passing into the abdomen usually turns dorsally for a short distance, where it enlarges to form an oval-shaped organ, the ventriculus or stomach. No cœcal tubes† have been found, but the surface of this mid-intestine is somewhat irregular, and it may be that the glandular areas in the wall of this organ will prove to function as cœcal glands.‡

Malpighian Tubes. Immediately below the mid-gut there arise on either side two tubes. These four tubes are of considerable length, and lie folded and doubled back on themselves above the mid-intestine and above and around the hind gut. These are the Malpighian tubules. Their natural position in the body is shown in fig. 2 pl. XLIII. Each tubule extends forward to cephalic end of stomach where, after making a loose double loop, it turns back to end with a half turn around rectal pouch. They are best studied in the male and freshly emerged female or in specimens treated for some time in 15

* Gordon Hewitt refers to a similar organ in the house fly as the crop.

† They are recorded as present in the larva of *Simulium* by Miall and Hammond.

‡ Haseman, 1910, considers a group of cells in the region of œsophageal valve of Psychola alternata as a reduced cœcal gland.

per cent chloral hydrate. Vaney, '02, finds that these tubes pass from the larva to the adult without any transformation, so that an examination of the larva gives a fair idea of their position in the adult. Just caudad of the region where the Malpighian tubules are attached, the hind gut takes a turn dorsally to a point below the junction of the fifth and sixth segments, and then bends caudad at right angles to about the seventh segment where the tube becomes first constricted and then dilated, especially on the lower side, which gives the appearance shown in r. p. fig. 2, pl. XLIII. This rectal enlargement is a transparent sac, the wall of which is distinctly striated (see Fig. 3, Pl. XLIII) and contains suspended from its upper or cephalic end six cone-shaped papillæ or glands, the rectal glands (see Fig. 3, RP). Each of these is made up of glandular cells containing large nuclei. An examination of the rectal pouch after treating it for some little time with caustic potash shows not only the estodermal origin of the papillæ but the presence of tracheal filaments as well.

Rectal papillæ have been observed in a number of insects. Chironomus has two, the house fly four, the stable fly four, most Hymenoptera, Neuroptera and Orthoptera six, Lepidoptera 60-200, and Coleoptera and Hemiptera none.*

Salivary Glands. The salivary glands are a pair of organs which lie in the fore part of the thorax on either side of but dorsally to the œsophagus. (Fig. 4.) They are connected with the common duct beneath the œsophagus by means of slender ducts. (See Fig. 4, Pl. XLIV.) They lie so close to the prothoracic wall and so near to the large tracheal trunks of the mesothoracic spiracle that they are often difficult to demonstrate. They lie on either side, between the second oblique and first longitudinal layer of muscle. Structurally they are in two parts. There is an upper part, which when stained shows itself to be glandular (see Fig. 4, Pl. XLIV) and a nonglandular part or sac. The glandular part is shown in sections to consist of thick-walled pouches, the cells of which contain large nuclei. In structure they resemble somewhat the acinous glands figured by Packard (after List): They do not at all resemble the trilobed glands of the mosquito or the slender glands of Stomoxys. They appear to be somewhat similar to those figured by Newstead for Phlebotmus.

* Miall and Hammond.

The Heart. This is shown in fig. 2 h., pl. XLIII. It lies along the dorsal wall of the abdomen till near the thorax, where it dips ventrally to a position just above the alimentary canal and extends forward, passing through a cellular mass above the region of the œsophagial valve and on into the head.*

The Fat Body. The fat body often occupies a considerable portion of the abdomen and is made up of many lobes. Figure 9 shows the fat bodies of a female fly after being fixed in alcohol for a time (ventral view).

The Nervous System. The nervous system is less specialized than in many other Diptera. The three thoracic ganglia are large while the five ganglia of the abdomen are comparatively small, the last two being close together and the terminal one larger than the others. (For general position and relative size see Fig. 6, Pl. XLIV.)

THE RESPIRATORY SYSTEM.

The respiratory system (Fig. 5, Pl. XLIV) consists of two longitudinal trunks running from the head to the posterior end of the abdomen. These are connected in the thorax by a large commissure, and in the head by a small one. The head and thorax are well supplied with large tracheal branches while the abdomen possesses a great network of tiny thread-like tubes arising from the rather small tracheal trunks. These little tubes ramify to all parts of the abdomen, binding together the loosely joined ova of the female, interlacing the many loops and folds of the Malpighian tubes and tying the fat body with all to the digestive canal. Thus we find in the abdomen on either side a longitudinal tracheal trunk, and throughout a mat of slender tracheal filaments. These tracheal trunks are not straight tubes, but curved at the six points where the branches leading to the abdominal spiracles are given off, namely, at the points between the second and third, third and fourth, fourth and fifth, in the fifth and in the sixth segments; the spiracular openings being located on the lateral surface of the body as follows: first one in the second segment near the junction of second and third, second one in third near the junction of second and third, third one in middle of segment 4, fourth one near the middle of segment 5, fifth one near the middle of segment 6, sixth one in seventh segment near its union with segment 6. These spiracles show up

* Gordon Hewett states that the dorsal vessel of the horse fly terminates in a mass of cells on dorsal side of ventriculus.

indistinctly as dark dots on the gray surface of the insect but show plainly in specimen treated with caustic potash. They are not functional in the larva and pupa, their work being taken over by the blood gills in the larva and by the cuticular gills in the pupa.

Taylor, '02, finds that the general scheme of tracheation is, however, about the same in the larva and pupa stages as in the adult, save for method by which the air is brought into the system mentioned above. His studies were upon *Simulium latipes*, and in his researches he records but five abdominal spiracle branches, failing to find the one in the second segment, which he thinks, however, must exist in view of the fact that the cast pupal skin shows an attached remnant of such a branch. He also infers that one exists in the first in some vestigial form, but I am unable to confirm this.

In the thorax there is a tendency of the tracheal branches to be dilated, and the fact that there are several large trunks or branches originating at the metathoracic spiracle and extending forward in different planes of the thorax makes it difficult to distinguish the main trunk from the others. In fact, if my interpretation is not incorrect, the main trunk is much smaller than the very large branches that are sent off. (See Fig. 5, Pl. XLIV.) This main trunk extends from the metathoracic spiracle underneath the large oblique thoracic muscles and runs along dorsolaterally to the fore gut, turning up before the first oblique muscle to meet the other branches extending from the mesothoracic spiracle. It then continues to the head where it breaks into many branches. These main trunks are connected in the thorax by one prominent commissure arising from the caudal end of the anterior third and looping up over the alimentary canal to the top of the second longitudinal muscles and thence back in the same plane between the right and left longitudinal thoracic muscles, joining the corresponding trunk on the other side. From the metathoracic spiracle there arise the following branches: one extending dorso-cephalad laterally to the main muscles of the thorax for some distance, then narrowing suddenly, it turns in under or between the outer oblique muscles, four and five, and gives off one small branch; another has the same general direction but lies in the plane between second oblique and first longitudinal and extends to the thoracic wall, where it turns ventro-cephalad at right angles and drops beneath the sixth

longitudinal muscle; another in this same plane extends ventrally, supplying the legs; while another leads forward to join the system again at the mesothoracic spiracle.

At the mesothoracic spiracle we find a number of branches, the direction of which may be best observed by referring to the drawings.

The mesothoracic spiracle lies well toward the front of the thoracic box and might well be mistaken for prothoracic in origin, but Taylor gives the following reason for considering it mesothoracic: Immediately in front of the anterior thoracic spiracle of the fly a well-marked apodeme or thickening of the cuticle runs obliquely backward to the mid-ventral line, where it unites with a similar thickening on the other side. The fore leg of the fly is inserted on the body in front of this apodeme, and muscles from the leg are attached to it. As the apodeme approaches the mid-ventral line, it bears the ante-furca, which, wherever it occurs, marks the junction of the pro and meso thorax. The anterior spiracle of the thorax lies close behind the apodeme which carries the antifurca, and is therefore mesothoracic in position.

Sexual Organs of the Female. The female *Simulium,* like most other related forms, possesses two ovaries, which lie on either side of the alimentary canal. (See Figs. 6 and 9.) These may occupy only the caudal third of the abdomen in case of the freshly emerged female, or take up all the available space in the abdominal cavity, even crowding into the thorax around the fore gut in case of females ready to oviposit.

When the newly emerged female is examined, the ovary appears as a transparent pouch showing practically no differentiation. But when this is removed and stained with borax carmine the ova are deeply stained and are seen to lie in regular order within the ovarian sheath. As the ova mature they lose their regularity of order and uniformity of shape, so that by the time they mature they are but loosely joined together and extremely irregular in outline. The latter is brought about by their crowded condition in the body of the insect. The eggs at maturity are relatively large, and when we are able to count as many as 276 ova packed in the body of a single female we do not wonder that they are so angular in form.

The oviduct connecting the ovarian sac with the exterior is comparatively easy to trace in the early adult stage. Here the oviducts are seen to join, forming a short tube, "the vagina," which passes to the genicular opening on the ventral side of the body between the penultimate and antipenultimate segments. (Fig. 8.) Dorsocaudad of the vagina lies a small chitinized spherical pouch, the spermathecæ. (Fig. 7.) This spermatheca is .09 mm. in diameter and dark-brown in color, with a thick chitinous covering. It is attached to the distal end of the common oviduct by a white cylindrical tube. The attachment of this white tube to this hard brown sphere reminds one of a germinating seed. It is interesting to note that with this fly there is but one functional spermatheca. In all the related species of flies that have been studied there are two—Phlebotomus, *Musca domestica*, *S. calcitrans*, Culex and the chironomids have two. When the genital apparatus is dissected and stained with borax carmine the two accessory pouches shown in figure 7 are found to be glandular in nature.

In concluding this brief sketch of the anatomy of the sand fly it may be well to state:

1st. That the three blood-sucking species studied for comparison of internal structures conform quite closely to the one here reported.

2d. That the digestive tract has three enlargements: the fore part of the proventriculus, the stomach, and the rectal pouch which contains six glandular rectal papillæ.

3d. That it is joined in the pharynx by the common duct of a pair of salivary glands which are located cephalo-dorsad to the proventriculus and well forward in the shoulder of the thorax, and at the junction of mid and hind gut, by four Malpighian tubules.

4th. That the reproductive organs are similar to those of related insects, save that but one spermatheca is found and this lies to the left side.

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Johannsen—Aquatic Insects.

PLATE I.

FIG. 1.—*Head of Cricket.*

This drawing shows the *epicranial suture* (*E. SU.*) which divides the paired sclerites from the single ones.

F.—The *front,* the first of these single sclerites, between the arms of the inverted Y of the suture, bears here the median ocellus and also the paired ocelli.

C.—The *clypeus.* The suture between the front and the clypeus is distinct. The clypeus is partly divided by a transverse suture; the part next the front is designated as *first clypeus* (*c1*), and that next the labrum as *second clypeus* (*c2*).

L.—The *labrum* is the last of the three single sclerites between the arms of the epicranial suture and the mouth. It is a single movable flap, constituting the upper lip of the mouth, having the appearance of an appendage, but in reality is a single sclerite, a portion of one of the head segments.

Tr.—*The trochantin of the mandible* is a small sclerite at the base of the *mandible* (*M*).

FIG. 2.—*Head of Cockroach.*

E. SU.—The *epicranial suture* is here present.

F.—The *front* bears the paired ocelli, but the median ocellus is absent.

C.—The *clypeus.* There is no suture between the front and the clypeus, but the *tentorium invaginations* (*at*) are quite distinct, and the dotted line connecting these points indicates the position of this obsolete suture. There is no distinct transverse suture dividing the clypeus, but the shading (indicated by second dotted line) gives the appearance of two parts.

L.—The *labrum* is present.

Tr.—The *trochantin* of the mandible is present.

FIG. 3.—*Head of the Larva of Corydalis.*

E. SU.—The *epicranial suture* here is very low down toward the mouth.

F.—The *front* is greatly reduced in comparison with the two forms already studied. The median and paired ocelli are wanting.

C.—The *clypeus.* Suture between front and clypeus is absent. Clypeus divided into three sclerites in transverse row, one on median line called *clypeus proper,* lateral sclerites called *antecoxal pieces of mandibles* (*ac*). Clypeus proper is divided by definite transverse suture into first and second clypeus (*c1* and *c2*).

Trochantin of mandible not visible.

At.—Tentorium invaginations present.

L.—*Labrum* present.

O. O.—The *occiput* as a definite area, formed of the upper portion of the postgenæ, is here shown back of vertex (*v*).

PLATE I—*continued.*

FIG. 4.—*Head of Walking-stick.*

E. SU.—*Epicranial suture* present but not so distinct.

F.—The *front* bears the ocelli.

C.—The *clypeus.* The suture between the front and the clypeus is obsolete, but the invaginations of the *tentorium,* though faint, are sufficient to mark the line of division. Transverse suture of the clypeus visible.

Ac.—*Antecoxal pieces* of the mandibles small.

Tr.—*Trochantin* of the mandible small but present.

L.—*Labrum* present.

FIG. 5.—*Head of Mantis.*

E. SU.—*Epicranial suture* small and indistinct.

F.—The *front* bears the median and paired ocelli. Transverse ridge of front so prominent that it appears at first sight to be division between front and clypeus.

C.—The *clypeus.* Presence of *tentorium* invaginations show that there is a strongly marked suture between the clypeus and front, instead of the upper ridge being the division. Clypeus undivided by sutures.

Ac.—*Antecoxal pieces* of mandibles small, merely indicated.

Tr.—*Trochantin* of mandibles present but very small.

FIG. 6.—*Head of Dahinia.*

E. SU.—*Epicranial suture* very indistinct; arms of Y form nearly straight line. Front might easily be considered part of epicranium.

F.—*Front.* Ocelli absent.

At.—*Tentorium* invaginations discernible. Suture between front and clypeus strongly marked.

C.—*Clypeus* divided by transverse suture.

Ac.—Position of *antecoxal pieces* apparent.

L.—*Labrum* apparently consisting of two parts, much like labrum of grasshopper.

Tr.—*Trochantin* of mandible present.

FIG. 7.—*Head of Orchelimum.*

E. SU.—*Epicranial suture* present only as fastigium of vertex (*v*).

F.—*Front* increased by pushing up of *E. SU.*; bears median ocellus.

C.—*Clypeus.* No suture between front and clypeus, but invaginations of tentorium very distinct. No transverse suture dividing clypeus, so that front and clypeus appear as one sclerite.

At.—*Tentorium* invaginations distinct.

Ac.—*Antecoxal* pieces not really discernable; position simply inferred on frontal margin of clypeus.

Tr.—*Trochantin* of mandible present.

L.—*Labrum* large.

PLATE I—*concluded.*

FIG. 8.—*Head of Decticinæ.*

E. SU.—*Epicranial suture* as in *Orchelimum.*

F.—*Front* containing trace of median ocellus.

C.—*Clypeus.* All divisions of clypeus indicated. Suture between front and clypeus present.

At.—*Tentorium* invaginations present.

L.—*Labrum* present.

Tr.—*Trochantin* of mandible present.

FIG. 9.—*Head of Grasshopper.*

E. SU.—*Epicranial suture* pushed up to point of vertex (*v*).

F.—*Front* large; bears ocelli.

C.—*Clypeus.* Suture between front and clypeus present. Divided by transverse suture into first and second clypeus.

Ac.—*Antecoxal pieces* indicated.

At.—*Tentorium* invaginations present.

L.—*Labrum* appears to be divided into two parts by transverse suture.

Tr.—*Trochantin* of mandible small but present as a distinct sclerite.

FIG. 10.—*Head and Neck of Cockroach.*

This drawing shows the lateral view of the epicranium, which includes all of the paired sclerites of the skull and sometimes also the front. The paired sclerites constitute the sides of the head and that portion of the dorsal surface that is behind the arms of the *E. SU.* These sclerites are so closely united that Straus-Durckheim considered them a single piece.

V.—*Vertex,* the portion of the epicranium which is next the front and between the compound eyes. In some insects it bears the paired ocelli, but not in the Plecoptera.

G.—*Genæ,* lateral portions of the epicranium.

Pg.—*Postgenæ.* The genæ are divided by a well-marked suture, which in the specimens at hand ended definitely. The part back of this suture is known as the postgena. When this suture continues to the epicranial suture the upper parts form the *occiput.*

Tr.—*Trochantin* of the mandible.

Md.—*Mandible.*

Mx.—*Maxilla.*

Mem.—*Maxillary* epimeron. A very small, narrow sclerite just back of the postgenæ.

This drawing also shows one dorsal, two lateral, and one ventral cervical sclerite.

FIG. 11.—*Head of Adult Corydalis, Ventral Aspect.*

This drawing shows a *gula,* a sclerite forming the ventral wall of the hind part of the head in certain orders of insects and bearing the labium or second maxillæ.

In the more generalized orders this sclerite or the one corresponding to it does not form a part of the skull.

PLATE I.

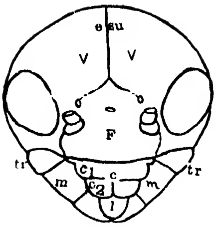
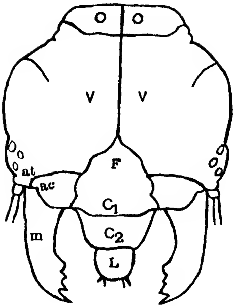


Fig. 1.



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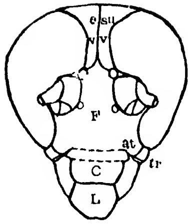

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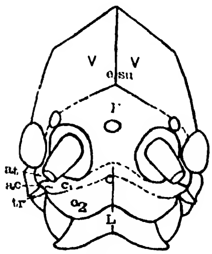
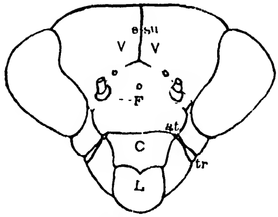


Fig. 4.



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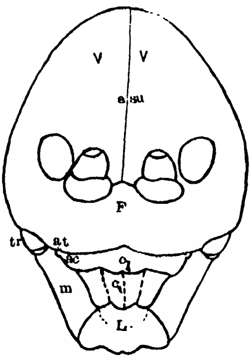

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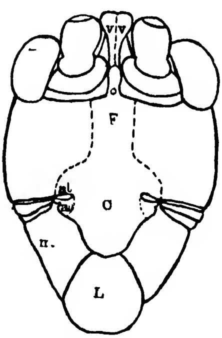

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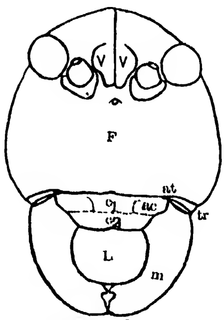

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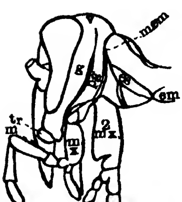

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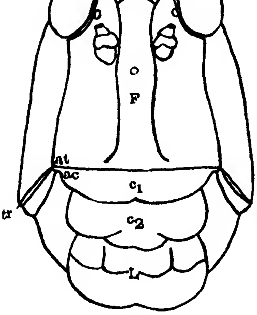

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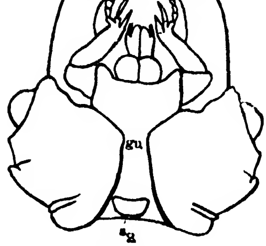


Fig. 11.

PLATE II.

FIG. 12.—*Embryo of a Damsel Fly (Calopteryx).*

(After Brandt.)

The question of the number of segments in the head of an insect has been much discussed. Savigny (1816) first made the suggestion, which has been accepted by all, that the movable appendages of the head were homodynamous with legs.

By methods of comparative anatomy, therefore, it has been found that there are at least four segments in the head: *i. e.*, the *antennal*, the *mandibular*, the *maxillary*, and the *second maxillary* or *labial*. The presence of a fifth segment (the ocular) has been suggested, as the compound eyes are borne on movable stalks in certain Crustacea, which might therefore place them among the movable appendages of the head.

The embryologists have taken up the question and Brandt (fig. 12) has shown in the embryo of the damsel fly that there are distinct segments, each corresponding to a pair of mouth-parts: *a*, antennal; *md*, mandibular; *mx*, maxillary; *2mx*, second maxillary.

The labial and maxillary segments appear to be body segments rather than cephalic. It is thought that perhaps "this represents a phylogenetic stage in which the head proper consisted of fewer segments than it does in existing insects."

FIG. 13.—*Embryo of Hydrophilus.*

(After Heider.)

Heider found that the subœsophageal ganglion which innervates the mandibles, maxillæ and labium is formed by the union of at least three pairs of primitive ganglia. His figure represents a stage in the development of *Hydrophilus*, in which these ganglia are still distinct, each pair of ganglia corresponding to a pair of mouth parts.

FIG. 14.—*Head of Embryo of Anurida.*

(After Folsom.)

FIG. 15.—*Section of the Head of an Embryo of Anurida.*

(After Folsom.)

The embryologists having confirmed the conclusions of comparative anatomy, have further demonstrated the existence of vestiges of segments. They have discovered a pair of ganglia between those of the mandibular and maxillary segments. (Fig. 14, *sl*; and fig. 15, *5*.)

FIG. 16.—*Head of Embryo of Acilius.*

(After Patten.)

As long ago as 1888 Patten figured the subœsophageal ganglion as consisting of four pairs of primary ganglia.

Some thought that the second of these four pairs of primary ganglia referred to the mandibular ganglia, because they are immediately in front of the maxillary; but according to the results of Folsom (figs. 14

and 15) and Uzel, the lingua arises between the maxillæ, and the superlingua between the maxillæ and the mandibles. Therefore, it is more probable that the first of these four pairs of ganglia (fig. 16, *1-4*) belongs to the mandibular segment and that the second pair are the homologues of the superlingual ganglia.

FIG. 17.—*Diagrams of the Elements of the Head.*

(After Comstock and Kochi.)

A.—Lateral aspect.

B.—Ventral aspect.

To illustrate the morphological relations of the arrangement of segments of the head, they are represented as distinct, of uniform size, and in a direct line:

First. Outline of segments made.

Second. Longitudinal line representing line of separation of sternal and pleural elements of segments.

Third. Chain of ganglia added, 1 pair for each segment.

Fourth. Compound eyes and the ocelli were represented in the first segment because innervated by the protocerebrum.

Fifth. Position of the appendages indicated, a pair to each segment except first. Antennæ to second segment because innervated by deutocerebrum.

Sixth. Mouth represented as opening in ventral wall of third segment.

FIG. 18.—*Ventral Aspect of the Metathorax of a Nymph of Pteronarcys.*

(After Comstock and Kochi.)

FIG. 19.—*Ventral Aspect of the Metathorax of Stenopelmatus.*

(After Comstock and Kochi.)

The position of the furca within the body is represented by a dotted line.

A typical segment is composed of: a ventral part, sternite; two lateral parts, pleurites; and a dorsal part, tergite.

Each thoracic segment is composed of two subsegments. The line separating these subsegments passes, on the pleural aspect, between the episternum and the epimeron; and on the tergal aspect, between the scutum and scutellum. The division on the sternal aspect is not so easily recognized, but it is clearly evident in the nymphs of *Pteronarcys* and *Stenopelmatus*. (Figs. 18 and 19, *s* and *s2*.)

The invaginations forming the furca lie in the suture between the two sclerites, and are therefore a landmark for determining the division between them.

FIG. 20.—*Ventral Aspect of the Meso- and Meta-thorax of Gryllus.*

The position of the furcæ within the body are indicated by dotted lines.

PLATE II—*concluded.*

FIG. 21.—*Diagram of a Segment of an Embryo.*

(After Heymons.)

Figure 20 shows that the sternellum is often obsolete, so that the furcæ appear to arise from the caudal margin of the segment.

Figure 21.—Heymons has shown that in a comparatively early embryonic stage each segment of the body is composed of three parts: a median field (*mf*), and two lateral fields (*lf*), and that the appendages are developed as evaginations of the lateral fields (*lg*).

Figure 20.—The abdominal sternites of the adult gryllus show the lateral elements of the sternites, the portion lying between the appendage and the median field (*lf*).

As a rule each sternite is an undivided sclerite.

FIG. 22.—*Ental Surface of the Pleurites of the Meso- and Meta-thorax of Melanoplus, Showing the Lateral Apodemes.*

The lateral apodemes show the line of union of the subsegments on the pleural aspect of a thoracic segment.

FIG. 23.—*The Base of a Leg of a Cockroach.*

This shows the relations of the appendages to a typical segment:

x, Point of pleural articulation of the coxa, ventral end of the foot of the lateral apodeme of the segment, the ventral end of the episternum (*es*), and epimeron (*em*).

y, Ventral articulation of the coxa; *sp*, spiracle; *ap*, apodeme; *ac*, antecoxal piece; *2ac*, second antecoxal piece; *tr*, trochantin; *es*, episternum; *em*, epimeron.

PLATE II.

Fig. 12.

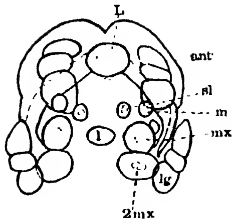


Fig. 14.

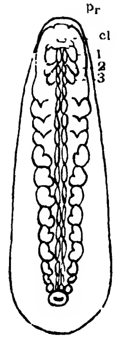


Fig. 13.

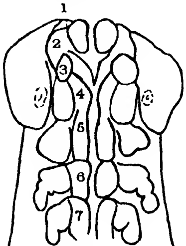
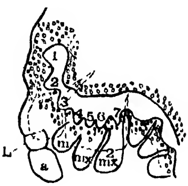


Fig. 16.



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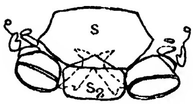


Fig. 19.

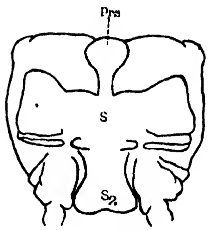


Fig. 18.

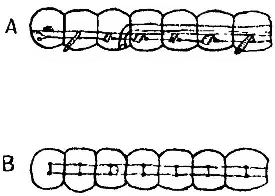
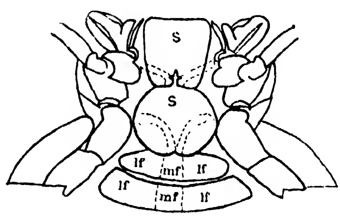


Fig. 17.



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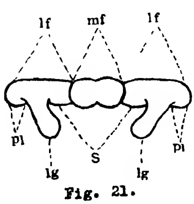


Fig. 21.

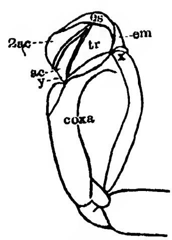


Fig. 23.

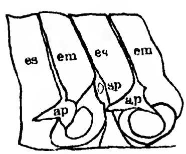


Fig. 22.

PLATE III.

FIG. 24.—*Head of a Cricket, Ental Surface of the Dorsal Wall.*

This shows: *os*, the ocular sclerites, which may be the basal segment of the ocular appendage; *as*, the antennal sclerite, which represents the lateral field of the antennal segment.

FIG. 25.—*Head of the Nymph of Pteronarcys.*

(After Comstock and Kochi)

In this the antennal sclerites (*as*) are distinct and closer to the clypeus than in the more specialized insects, showing that it is possible that they were once closely connected with the clypeus (*c*) and a part of the same segment.

FIG. 26.—*Lateral Cervical Sclerites of Melanoplus.*

These are taken to represent the epimeron (*em*) and episternum (*es*) of the labial segment.

There is present a prominent apodeme (*ap*), and the epimeron connects with the episternum of the prothorax, and the episternum (*es*) with what is considered the epimeron of the maxillary segment.

FIG. 27.—*Head of Stenopelmatus, Ventral Aspect.*

(After Comstock and Kochi)

This shows the ventral cervical sclerites in two transverse series, *S* and *S2*. These may be regarded as the sternum and sternellum of the labial segment.

FIG. 28.—*Ventral and Lateral Cervical Sclerites of Periplaneta.*

This shows the two single cervical sclerites—the sternum (*s*) and the sternellum (*s2*) of the labial segment; also the lateral cervical sclerites —the episternum (*es*) and the epimeron (*em*) of the labial segment.

FIG. 29.—*Ventral Cervical Sclerites of Gryllus.*

In *Gryllus,* as in *Stenopelmatus* the ventral cervical sclerites are arranged in two transverse series.

FIG. 30.—*Hypopharynx of Melanoplus.*

This shows the lingua (*l*) and the superlinguæ (*sl*), the sole remaining traces of the superlingual segment. These are small sclerites, probably representing the appendages of that segment.

This also shows the pharyngeal sclerites (*ps*), the sternal elements of the mandibular segment.

FIG. 31.—*Head of a Cricket, Caudal Aspect.*

Pg.—Postgenæ.
Es.—Episternum.
Em.—Epimeron.
M. ap.—Mandibular apodeme.
Bt.—Body of tentorium.
Ex. h.—Extensors of the head.
D. ap.—Dorsal apodeme.

This is to show the parts that are considered as belonging to the mandibular segment.

PLATE III—*concluded.*

M. ap. is the acetabulum into which a condyle of the mandible fits, and which is the beginning of a suture which divides the *pg.* into two parts, the episternum and the epimeron. "The mandible is the basal segment (coxa) of an appendage, which articulates with the ventral ends of two sclerites (episternum and epimeron), between which there is a lateral apodeme."

FIG. 32.—*The Tentorium of a Cockroach, Dorsal Aspect.*

Pt.—Posterior arm of tentorium.
Bt.—Body of tentorium.
Fp.—Frontal plate of tentorium.
Dt.—Dorsal arm of tentorium.
T. oe.—Tendons of œsophageal muscles.
At.—Anterior arm of tentorium.
C.—Clypeus.
L.—Labrum.

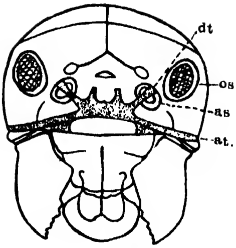
FIG. 33.—*Head of Melanoplus, Caudal Aspect.*

V.—Vertex.
O.—Occiput.
Pg.—Postgenæ.
Pt.—Posterior arm of tentorium.
Bt.—Body of tentorium.
Mx.—Maxillæ.
2nd Mx.—Second maxillæ or labium.

FIG. 34.—*Tentorium of Melanoplus, Cephalic Aspect.*

The distal ends of the dorsal arms detached.
O.—Occiput.
Pg.—Postgenæ.
Pt.—Posterior arms of tentorium.
Bt.—Body of tentorium.
At.—Anterior arms of tentorium.
C.—Clypeus.
L.—Labrum.

PLATE III.



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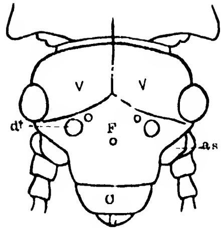

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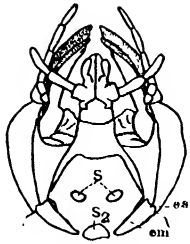

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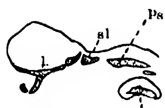

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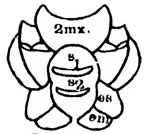


Fig. 28.

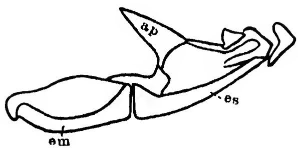


Fig. 26.

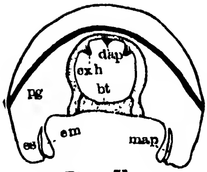


Fig. 31.

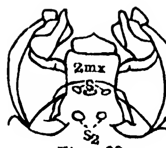
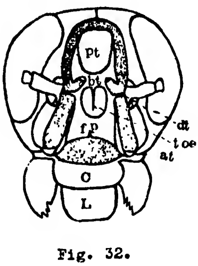


Fig. 29.



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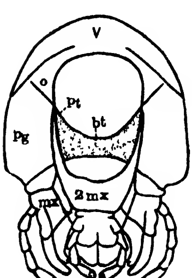


Fig. 33.

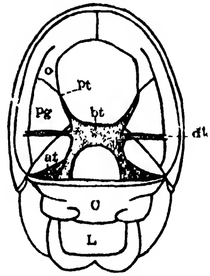


Fig. 34.

PLATE IV.

FIG. 35.—*Head of Amblychila cylindriformis.*

O.—Occiput.
V.—Vertex.
F.—Front.
C.—Clypeus.
L.—Labrum.
G.—Gena.
Tr.—Trochantin of the mandible.
Md.—Mandible.
At.—Anterior arm of tentorium.
Esu.—Epicranial suture.

FIG. 36.—*Head of Amblychila cylindriformis, Ventral Aspect.*

Pg.—Postgenæ.
Gu.—Gula.
Dt.—Dorsal arm of tentorium.
Em.—Epimeron.
a.—Small chitinized spots, which may be remnants of lateral cervical sclerites.

FIG. 37.—*Head of Amblychila cylindriformis.*

O.—Occiput.
Es.—Episternum.
Dt.—Dorsal arm of tentorium.
Em.—Epimeron.
Pg.—Postgena.
Gu.—Gula.
a.—Chitinized spot.

FIG. 38.—*Sclerites of Neck.*

Legend as above. *S2.*—Sternellum.

FIG. 39.—*Tentorium of Amblychila, Dorsal Aspect.*

Bt.—Body of tentorium.
Dt.—Dorsal arm of tentorium.
At.—Anterior arm of tentorium.
Os.—Ocular sclerite.

PLATE IV.

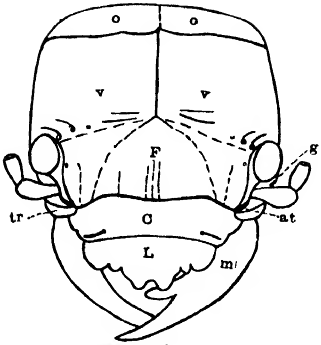


Fig. 35.

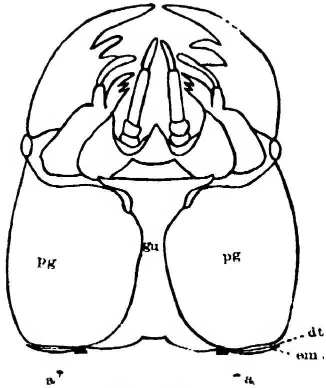


Fig. 36.

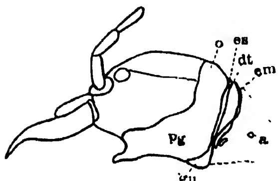


Fig. 37.

Fig. 38.

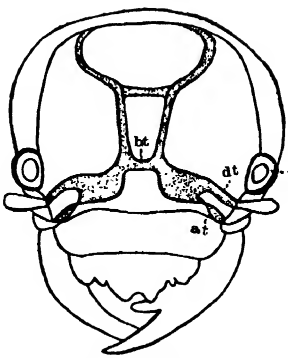


Fig. 39.

PLATE V.

FIG. 1.—Dorsal aspect of *Entylia sinuata*. Prothorax removed. *a*, head; *d*, compound eye. Mesathorax: *b*, præscutum; *c*, scutum; *f*, scutellum; *e*, post-scutellum. Metathorax: *g*, præscutum; *h*, scutum; *i*, scutellum; *k*, post-scutellum.

FIG. 2.—Metathoracic leg of *Entylia sinuata*. *a*, coxa; *b*, trochanter; *c*, femur; *d*, tibia; *e*, tarsi; *f*, claws.

PLATE V.

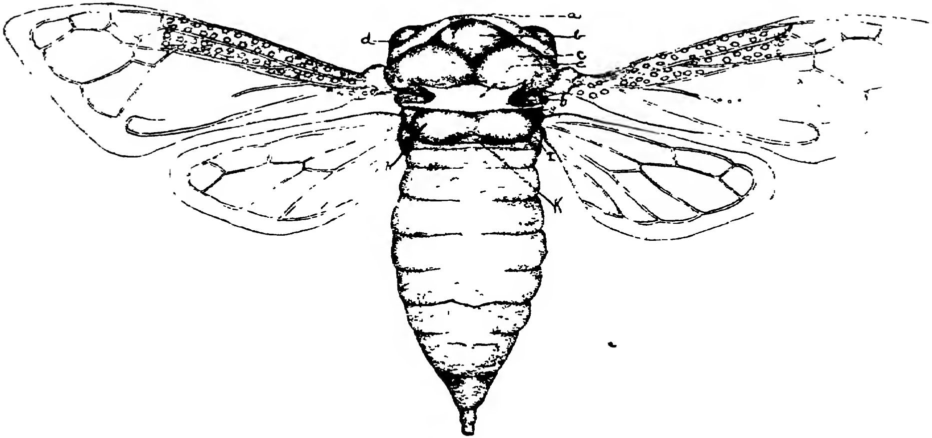


Fig.-I

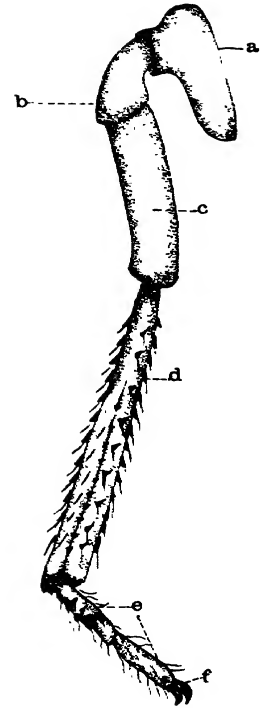


Fig.-2-

PLATE VI.

FIG. 5.—Dorsal aspect of *Ceresa bubalus*. *a*, metopidium; *b*, dorsum; *c*, posterior process; *d*, tegmina; *e*, suprahumeral.

FIG. 6.—Prothorax of *Ceresa diceros*.

FIG. 7.—Lateral aspect of *Ceresa bubalus*. *x*, humeral angle.

FIG. 8.—Prothorax of *Ceresa taurina*.

FIG. 9.—Front aspect of head of *Ceresa taurina*.

FIG. 10.—Front aspect of head of *Ceresa bubalus*. *a*, metopidium crest; *b*, front of metopidium; *c*, compound eye; *d*, ocelli; *e*, antennæ; *f*, clypeus.

PLATE VI.

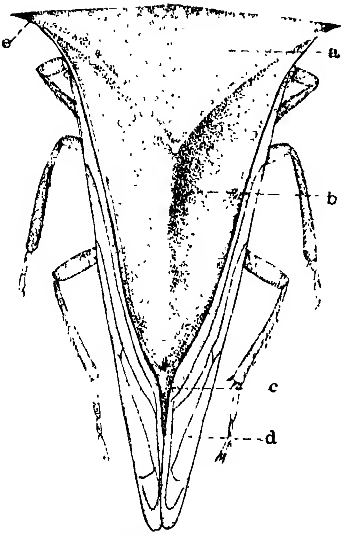
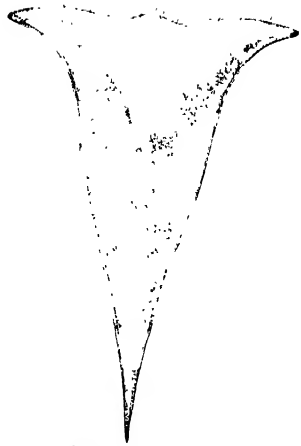


Fig. 5.



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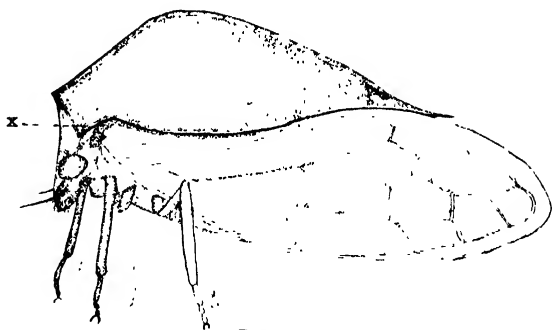

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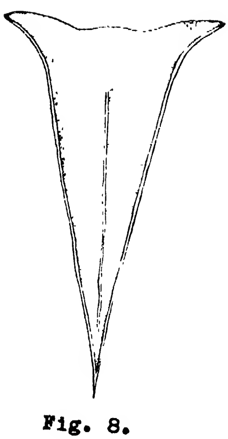

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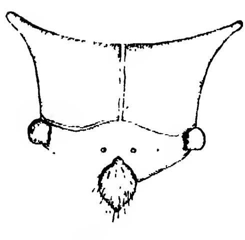

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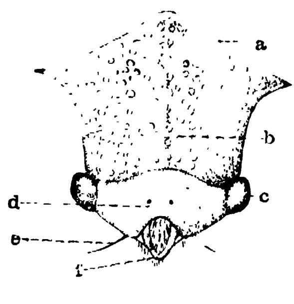


Fig. 10.

PLATE VII.

FIG. 11.—Lateral aspect of *Campylenchia curvata*. *a*, procephalon; *b*, metopidium.

FIG. 12.—Cephalic aspect of *Enchenopa binotata*. *c*, procephalon; *d*, metopidium; *e*, suprahumeral.

FIG. 13.—Lateral aspect of *Enchenopa binotata*.

FIG. 16.—Cephalic aspect of head of *Stictocephala inermis*. *g*, metopidium sloping backward; *f*, front of metopidium.

FIG. 17.—Lateral aspect of *Stictocephala inermis*.

PLATE VII.

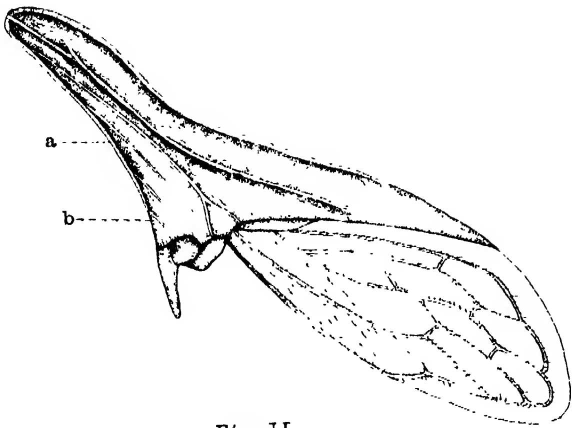


Fig.11-

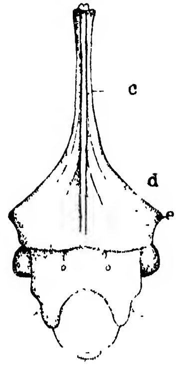


Fig.-12-

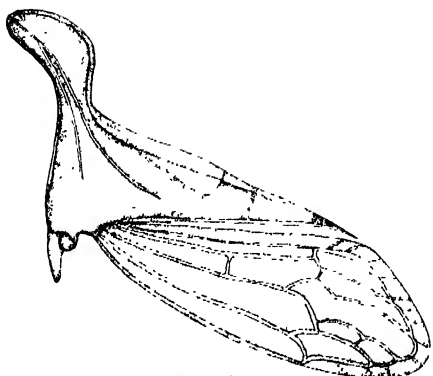


Fig.- 13-

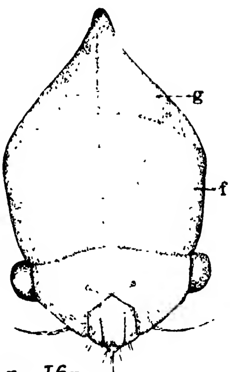


Fig.-16-

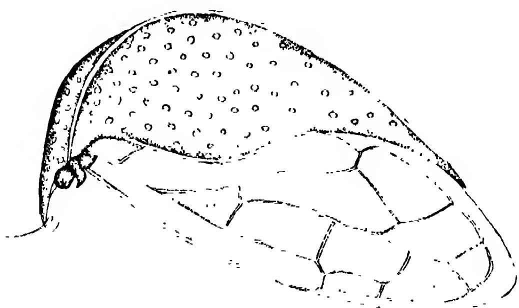


Fig.-17-

PLATE VIII.

FIG. 14.—Cephalic aspect of head of *Vanduzea arquata.*

FIG. 15.—Lateral aspect of *Vanduzea arquata.*

FIG. 18.—Cephalic aspect of head of *Acutalis tartarea.*

FIG. 19.—Lateral aspect of *Acutalis tartarea.*

FIG. 20.—Cephalic aspect of *Micrutalis calva.*

FIG. 21.—Lateral aspect of *Micrutalis calva.*

FIG. 30.—Cephalic aspect of *Telamona pyramidata.*

FIG. 31.—Lateral aspect of *Telamona pyramidata.*

PLATE VIII.

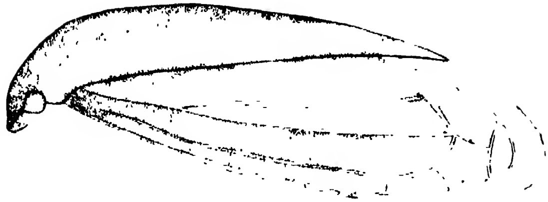


Fig.-I9-

Fig.-I4-

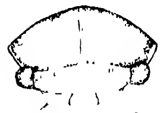


Fig. -20-

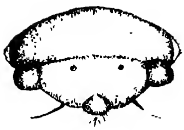


Fig. -I8-

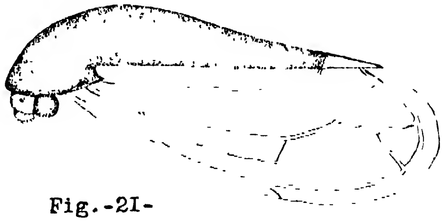


Fig.-2I-

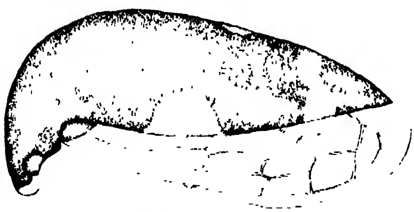
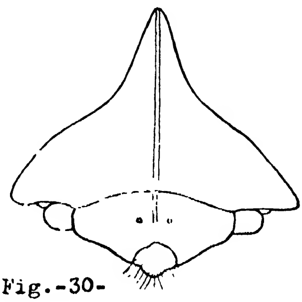


Fig.-I5-



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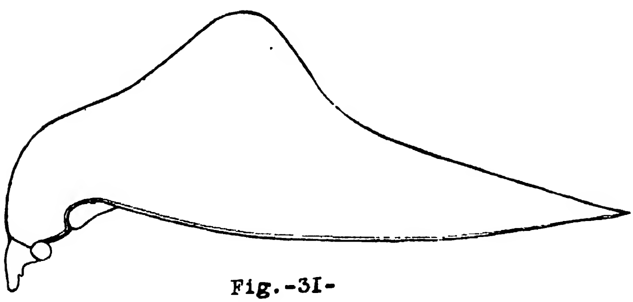


Fig.-3I-

PLATE IX.

FIG. 22.—Cephalic aspect of *Archasia galeata*.

FIG. 23.—Lateral aspect of *Archasia galeata*.

FIG. 24.—Cephalic aspect of *Cyrtolobus vau*.

FIG. 25.—Lateral aspect of *Cyrtolobus vau*.

FIG. 26.—Cephalic aspect of *Publilia concava*.

FIG. 27.—Lateral aspect of *Publilia concava*.

FIG. 28.—Cephalic aspect of *Stictocephala lutea*.

FIG. 29.—Lateral aspect of *Stictocephala lutea*.

PLATE IX.

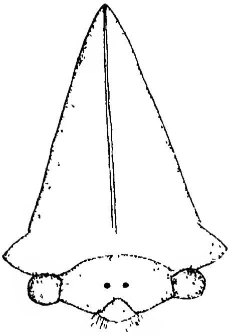
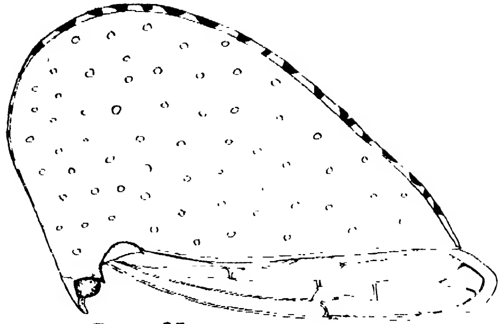


Fig.-22-



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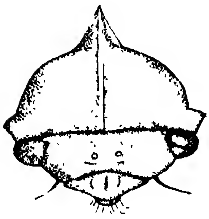
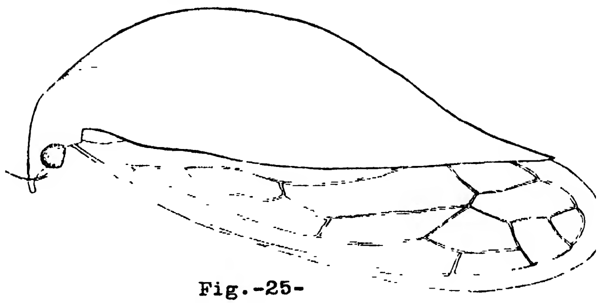


Fig.-24-

Fig.-27-

Fig.-26-



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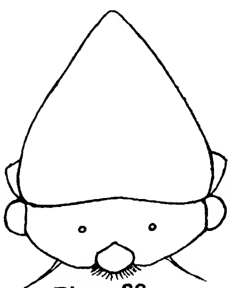


Fig.-28-

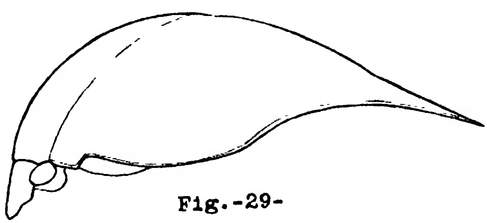


Fig.-29-

PLATE X.

FIG. 32.—Cephalic aspect of the head of *Publilia modesta.*

FIG. 33.—Lateral aspect of *Publilia modesta.*

FIG. 34.—Lateral aspect of prothoracic arm, showing position and connection to coxa of prothoracic leg. *b*, cavity for head; *c*, coxa of leg; *d*, under sclerite of prothoracic arm; *e*, prothoracic arm; *f*, indentation where compound eye fits.

FIG. 73.—Lateral aspect of *Telamona ampelopsides.*

FIG. 74.—Cephalic aspect of *Telamona ampelopsides.*

PLATE X.

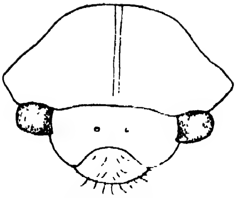


Fig.-32-

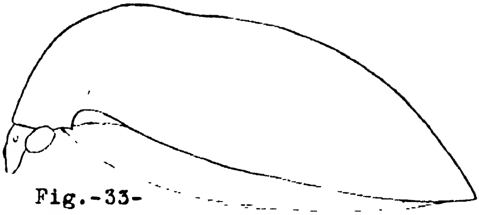


Fig.-33-

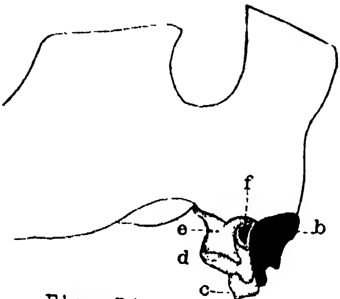


Fig.-34-

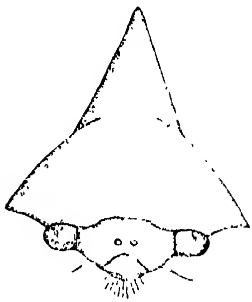


Fig. 74.

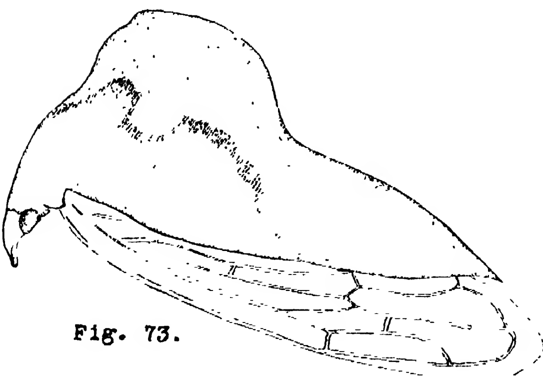


Fig. 73.

PLATE XI.

FIG. 35.—Cephalic aspect of head of *Entylia sinuata*. *e*, epicranium; *s*, epicranial suture; *o*, ocelli; *c*, compound eye; *l*, loræ; *y*, clypeus (cephalic face); *a*, antennæ.

FIG. 36.—Antennæ of *Entylia sinuata*. *s*, socket; *m*, basal segment; *n*, second segment bearing sensoria; *t*, third segment; *x*, hairlike termination of the third segment.

FIG. 37A.—Ventral aspect of head of *Entylia sinuata*. *x*, epicranium; *o*, ocelli; *c*, compound eye; *a*, antennæ; *g*, genæ; *f*, cephalic face of clypeus; *y*, ventral face of clypeus; *m*, mandibular sclerite; *n*, maxillary sclerite; *lb*, labrum; *p*, epipharynx; *l*, the three joints of the beak, called labium; *s*, maxillary setæ.

FIG. 37B.—*m*, tip of mandibular setæ; *n*, tip of maxillary setæ.

FIG. 38A.—Lateral aspect of head of *Entylia sinuata*. *c*, compound eye; *d*, cephalic face of clypeus; *y*, ventral face of clypeus; *l*, labrum; *e*, epipharynx; *g*, gena; *m*, mandibular sclerite; *x*, maxillary sclerite; *n*, floor of mouth; *k*, the three joints of the labium.

PLATE XI.

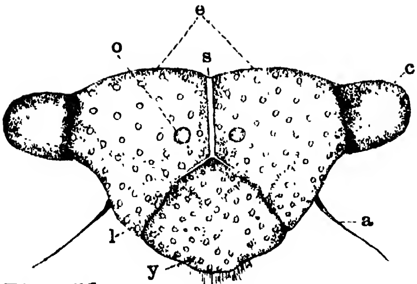


Fig.-35-

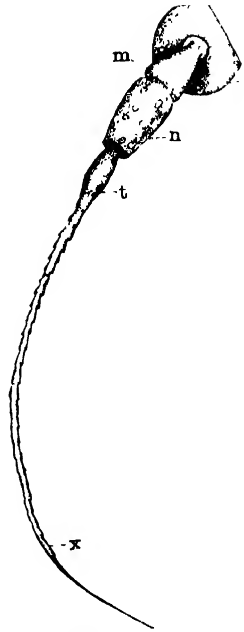


Fig.-36-

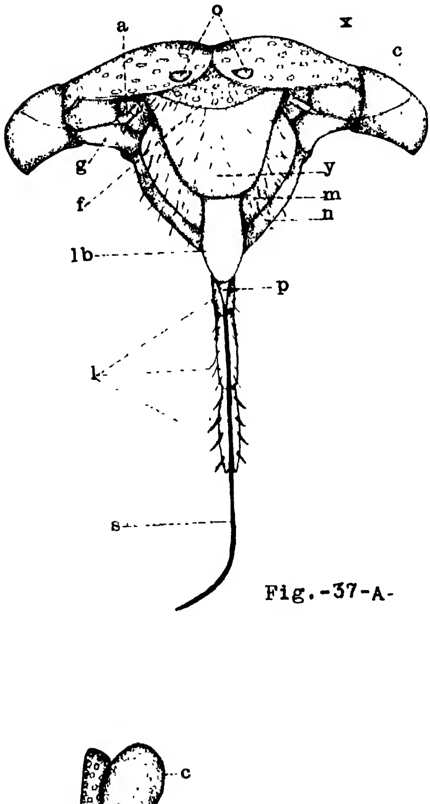


Fig.-37-A-

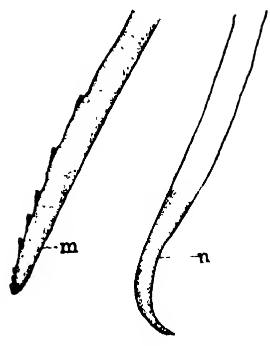


Fig.-37-B-

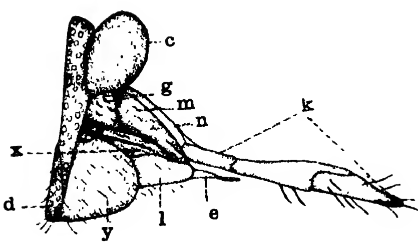


Fig.-38-A-

PLATE XII.

FIG. 38B.—Beak of *Entylia sinuata*. *b*, tip of labrum; *p*, epipharynx; *l*, labium; *n*, seta of maxillæ.

FIG. 39.—Interior of front of mouth. *y*, clypeus; *x*, mandibular sclerite; *n*, distal tip of mandibular sclerite; *h*, hypopharynx; *e*, grooved inner surface of epipharynx; *z*, tip of epipharynx, the portion beyond labrum; *l*, edge of labrum, curving inward to help hold setæ.

FIG. 40.—View of the head on the side resting against the body. *y*, cavity into head; *m*, muscle holding head to thorax; *e*, epicranial suture; *o*, occiput; *c*, compound eye; *t*, tentorium, with its branches which lead into the head and thorax; *r*, rod which supports the labium; *n*, floor of mouth; *x*, maxillary sclerites; *l*, three joints of the labium.

FIG. 41.—Back of head, with one maxillary sclerite removed to show the mandibular sclerite which lies in front of it. *o*, occiput; *x*, maxillary sclerite; *p*, maxillary process which guides the setæ; *s*, maxillary seta; *y*, muscle connecting the maxillary seta to the sclerite; *m*, mandibular sclerite; *b*, mandibular seta; *v*, shows the articulating joint which connects the seta to the sclerite; *n*, muscle which holds the mandibular seta to the cranium.

FIG. 42.—Cephalic aspect of the head, with the mandibular and maxillary sclerites pulled apart. *e*, epicranium; *c*, front face of the clypeus; *y*, ventral face of the clypeus; *d*, mandibular sclerite; *x*, maxillary sclerite. The cross indicates where the seta is joined to the sclerite.

PLATE XII.

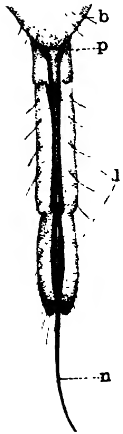


Fig.-38-B-

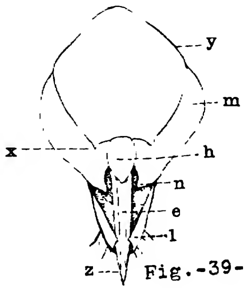


Fig.-39-

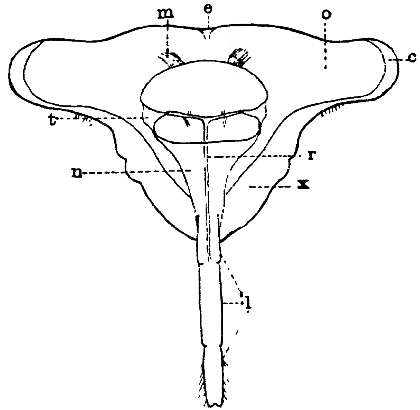


Fig.40-

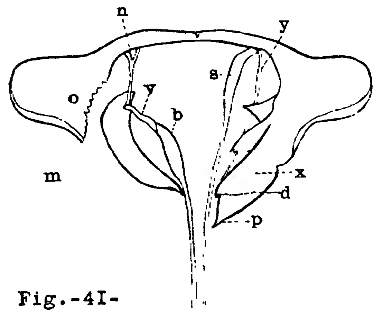


Fig.-4I-

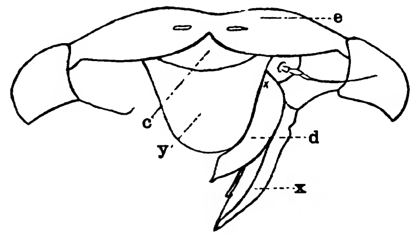


Fig.-42-

PLATE XIII.

FIG. 43.—Section through the first segment of the beak. *a*, support rod; *b*, inner edge of beak; *c*, outer edge of beak; *d*, edge of labrum; *e*, mandibular setæ, showing opening to form a tube; *f*, maxillary setæ, showing the manner in which the two are grooved together to form the tube.

FIG. 44.—Section through the second segment of the beak. *a*, indentation for support rod; *b*, outer edge of beak; *g*, inner edge of beak; *d*, epipharynx; *e*, mandibular setæ; *f*, maxillary setæ.

FIG. 45.—Section through the middle of the third or last segment of the beak. *a*, indentation for support rod; *b*, inner wall of beak; *c*, outer wall of beak; *f*, maxillary setæ; *e*, mandibular setæ; *m*, muscles.

FIG. 46.—Section through the tip of the beak. *a*, indentation for support rod; *c*, *b*, outer wall; *x*, maxillary setæ; *m*, muscles.

FIG. 47.—Cross section of the head, the plane being parallel with the cephalic face. *p*, ring of the pharynx; *x*, maxillary setæ; *d*, mandibular setæ; *y*, clypeus; *m*, muscles supporting the clypeus; *xs*, maxillary sclerite; *ds*, mandibular sclerite.

PLATE XIII.

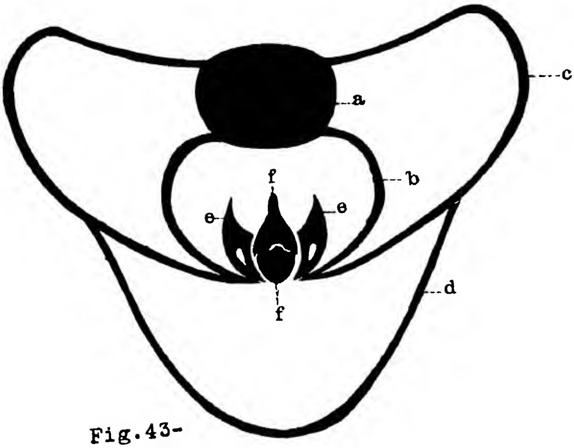


Fig.43-

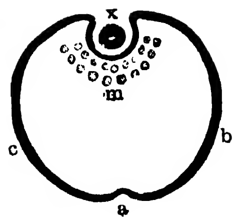


Fig.-46-

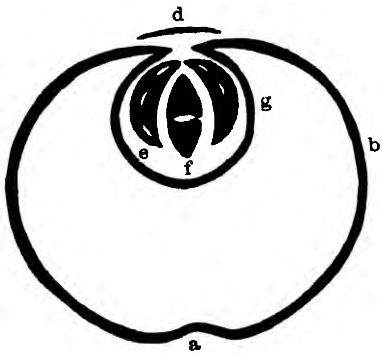


Fig.-44-

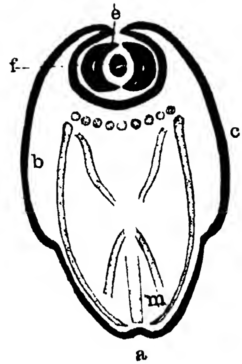


Fig.-45-

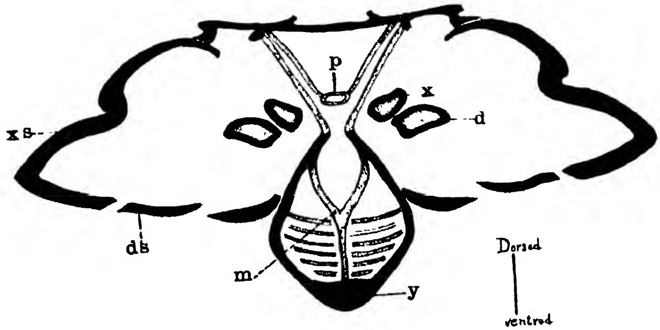


Fig.-47-

PLATE XIV.

FIG. 48.—Cross section parallel with the beak and maxillary sclerite. *e*, compound eye; *o*, optic nerve; *h*, ring of pharynx; *x*, maxillary seta; *a*, muscle holding the seta to the cranium; *r*, retractor; *p*, protractor muscles; *d*, mandibular seta; *t*, retractor; *n*, protractor; *c*, pumping muscles; *m*, muscles which operate the pharynx near the epipharynx.

FIG. 49.—Cross section near the back of the head parallel with the cephalic face. *b*, lower brain; *s*, upper brain; *h*, œsophagus; *m*, muscle which supports the œsophagus; *x*, maxillary seta; *o*, optic nerve.

FIG. 51.—Ventral aspect of the reproductory organs of the male. *a*, last abdominal segment; *s*, subgenital plate; *r*, claspers; *x*, *z*, claspers; *k*, copulatory organ; *y*, anal plates.

FIG. 52.—Lateral aspect of the tip of the abdomen of the male. *y*, supra-anal plate; *p*, cercus; *r*, claspers; *x*, *z*, claspers; *y*, anal plate, bearing the copulatory organ on its ventral side.

PLATE XIV.

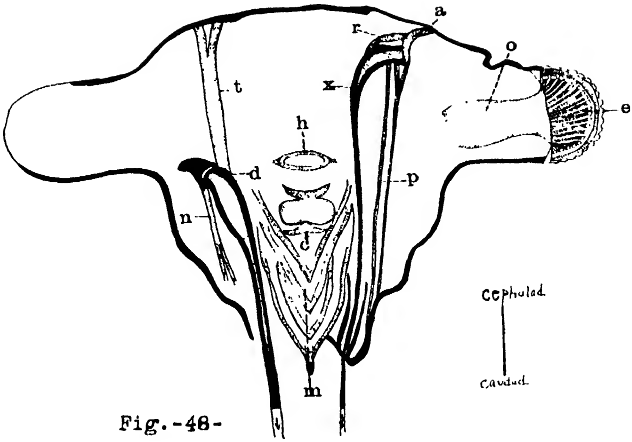


Fig.-48-

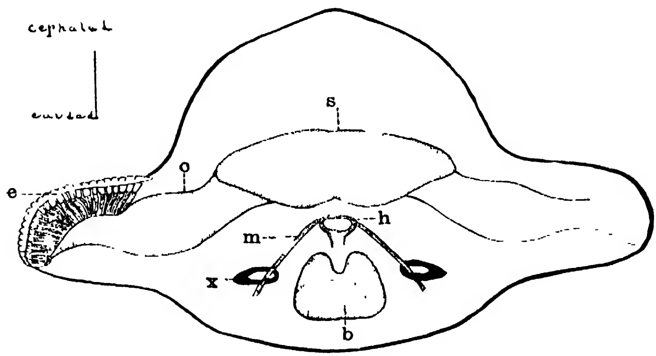


Fig.-49-

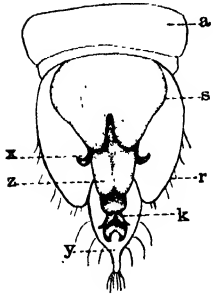


Fig.-51-

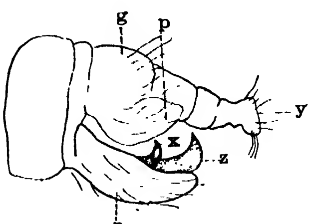


Fig.52-

PLATE XV.

FIG. 50.—Longitudinal section of the head. *a*, back of beak lying against the sternum; *b*, supraœsophagal ganglion, or upper brain; *e*, subœsophagal ganglion, or lower brain; *r*, support rod; *p*, pumping muscles, or salivary ejaculator; *k*, duct leading from salivary glands; *o*, duct from salivary ejaculator (*p*) to œsophagus; *f*, floor of mouth; *v*, muscles; *j*, muscles; *x*, maxillary seta; *g*, epipharynx; *l*, labrum; *n*, muscles governing pharynx; *u*, muscles governing pharynx; *z*, clypeus (ventral face); *y*, clypeus (cephalic face); *t*, *m*, muscles supporting clypeus; *h*, hypopharynx.

FIG. 53.—Ventral aspect of the tip of the female abdomen. *v*, ventral plate; *g*, supra-anal plate; *r*, egg guides; *e*, claspers; *o*, oviducts; *y*, anal plates.

FIG. 54.—Lateral aspect of the tip of the female adbomen. *g*, supra-anal plates; *y*, anal plates; *gs*, subgenital plates; *r*, claspers; *e*, egg guides; *v*, last ventral segment of the abdomen.

PLATE XV.

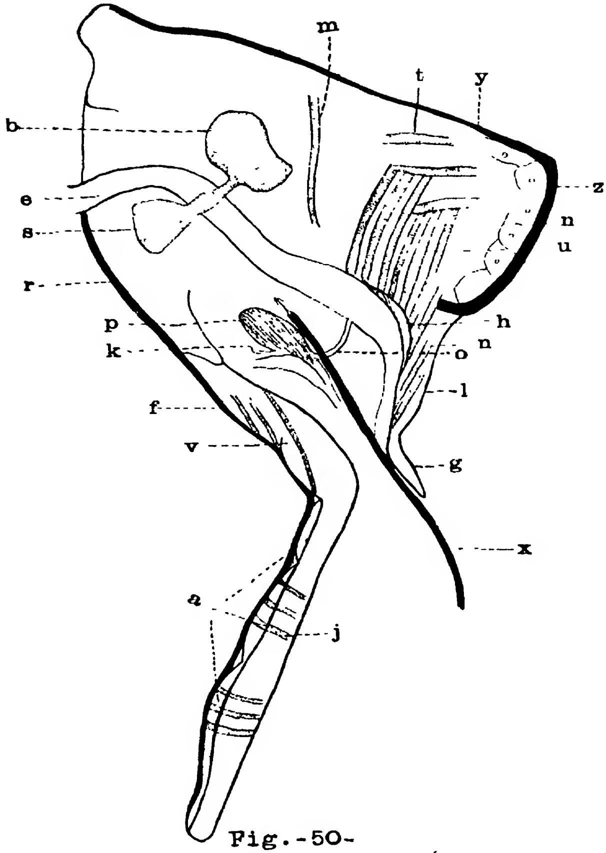
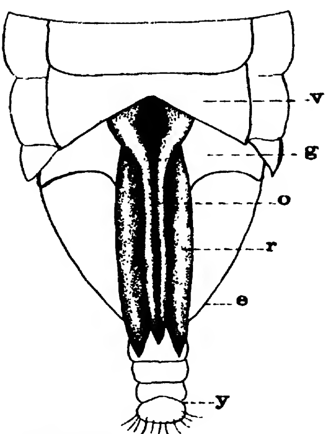


Fig.-50-



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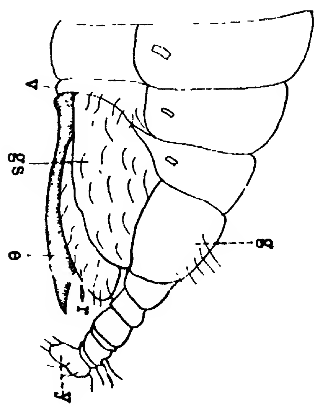


Fig.-54-

PLATE XVI.

FIG. 55.—Leaf of *Cnicus altissimus*, showing, at *A*, the egg mass laid by *Entylia sinuata.*

FIG. 56.—*B*, enlarged drawing of vein containing egg mass. The vein is burst open. *C*, an egg enlarged 31 times; *x*, micropyle.

FIG. 57.—Ventral aspect of newly hatched nymph of *Entylia sinuata.*

FIG. 58.—Dorsal aspect of nymph of *Entylia sinuata* after first moult.

FIG. 59.—Lateral aspect of nymph of *E. sinuata* after second moult.

FIG. 60.—Lateral aspect of nymph of *E. sinuata* after third moult and just preceding the adult stage. This is the pupa.

FIG. 61.—Lateral aspect of *E. sinuata.*

FIG. 62.—Cephalic aspect of the head of *E. sinuata.*

PLATE XVI.

Fig.-55-

Fig.-56-

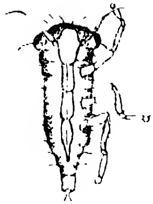


Fig. 57-

Fig.58-

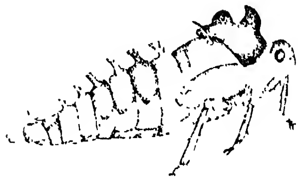


Fig.-59-

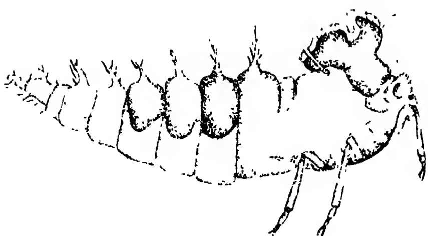


Fig. 60-

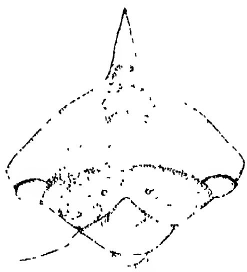


Fig. 62-

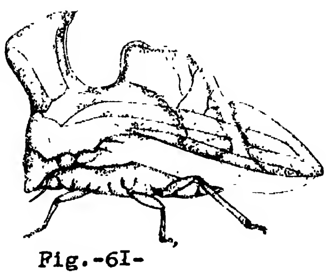


Fig.-6I-

PLATE XVII.

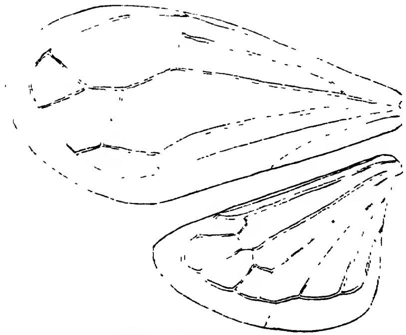
FIG. 63.—Tegmina and wing of *Micrutalis calva.*

FIG. 64.—Tegmina and wing of *Entylia sinuata.*

FIG. 65.—Tegmina and wing of *Publilia concava.*

FIG. 67.—Tegmina and wing of *Cyrtolobus vau.*

PLATE XVII.



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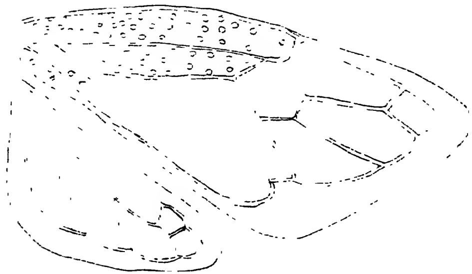
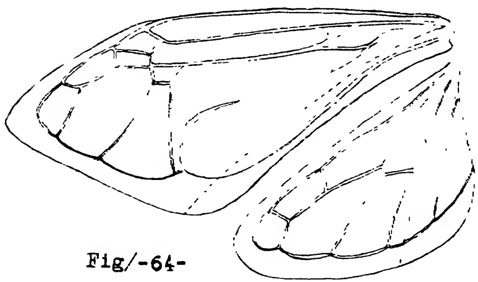


Fig.-65-



Fig/-64-

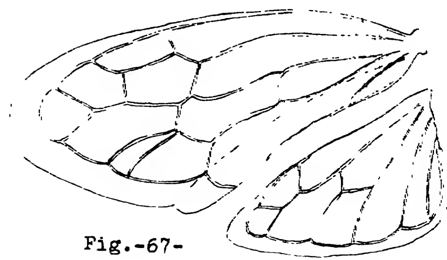


Fig.-67-

PLATE XVIII.

FIG. 66.—Tegmina and wing of *Stictocephala inermis.*

FIG. 68.—Tegmen of species determined in K. U. collection as *Vanduzea vestita.*

FIG. 69.—Tegmen and wing of *Vanduzea arquata.*

FIG. 70.—Tegmen and wing of *Campylenchia curvata.*

PLATE XVIII.

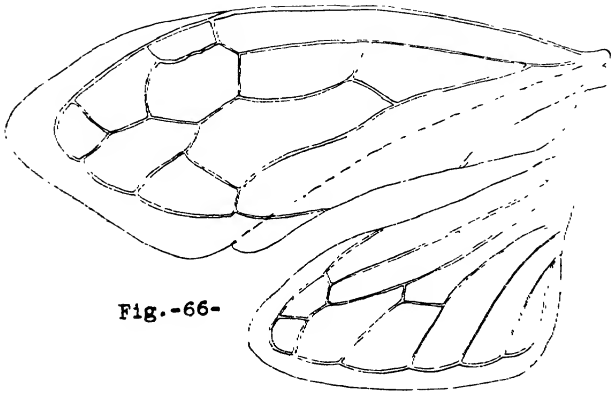


Fig.-66-

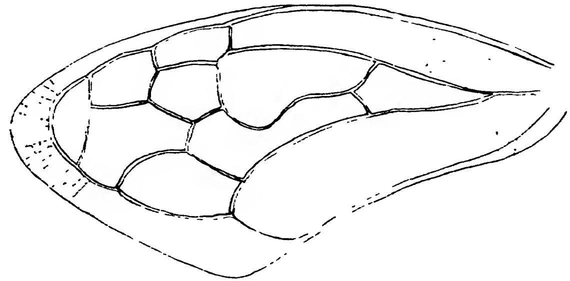


Fig.68-

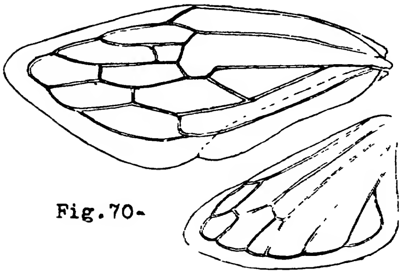


Fig.70-

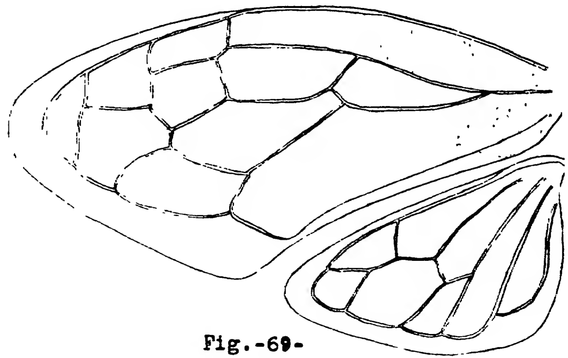


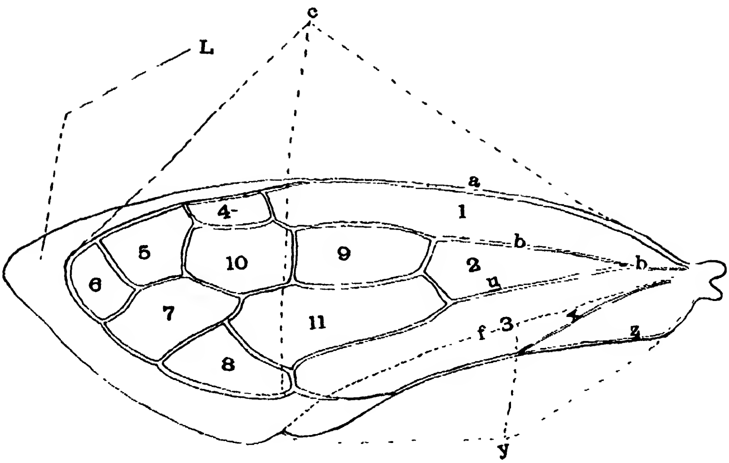
Fig.-69-

PLATE XIX.

FIG. 71.—Tegmen and wing of *Enchenopa binotata*.

FIG. 75.—Tegmen of *Ceresa bubalus* with veins and cells named. *L*, limbus or membrane; *c*, corium or embolium; *a*, costa; *b*, radia; *u*, ulnar; *x*, *z*, anals; *1*, *2*, *3*, basal cells; *3*, also sutural area; *f*, sutural fold; *9*, *10*, *11*, discoidal cells; *4*, *5*, *6*, *7*, *8*, apical cells; *6*, terminal apical cell; *y*, clavus.

PLATE XIX.



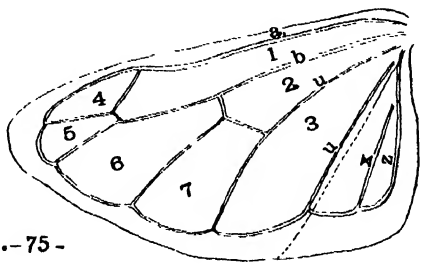


Fig.-75-

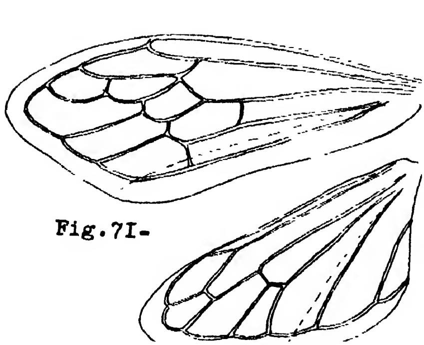


Fig.71-

PLATE XX.

FIG. 76.—Legs of *E. sinuata.* *a*, prothoracic leg; *b*, mesothoracic leg; *c*, **metathoracic leg.**

FIG. 77.—Legs of *Campylenchia curvata.* *a*, prothoracic leg—the coxa **and femur** have separated; *b*, mesothoracic leg; *c*, metathoracic leg.

FIG. 78.—Tegmen of *Vanduzea arquata.*

FIG. 79.—Tegmen of *Cyrtolobus vau.*

FIG. 80.—Tegmen of *Acutalis tartarea.*

FIG. 81.—Tegmen of *Micrutalis occidentalis.*

FIG. 82.—Tegmen of *Micrutalis calva.*

FIG. 83.—Tegmen of *Entylia sinuata.*

FIG. 84.—Tegmen of *Telamona pyramidata.*

PLATE XX.

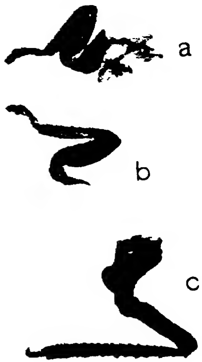


Fig.-76-


Fig.-78-

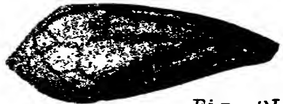


Fig.-8I-


Fig.-82-


Fig.-79-


Fig.-83-

Fig/-77-


Fig.-80-


Fig.-84-

PLATE XXI.

FIG. 3.—Cercopidæ.
FIG. 4.—Cicadidæ.
FIG. 85.—Tegmen of *Enchenopa binotata.*
FIG. 86.—Tegmen of *Campylenchia curvata.*
FIG. 87.—Tegmen of *Ceresa bubalus.*
FIG. 88.—Tegmen of *Ceresa diceros.*
FIG. 89.—Tegmen of *Stictocephala inermis.*
FIG. 90.—Tegmen of *Stictocephala lutea.*

PLATE XXI.

Fig.-86-

Fig.-88-

Fig. 3.

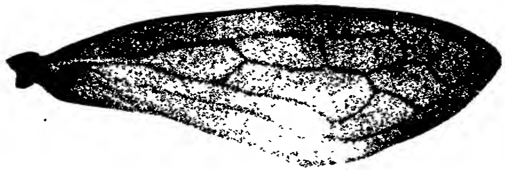


Fig.-87-

Fig.90-

Fig. 4.

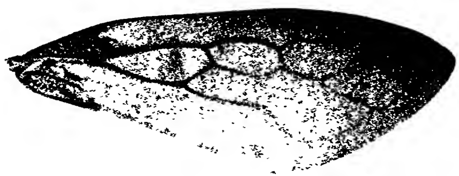


Fig.-8

Fig.-85

EXPLANATION OF PLATES.

(All figures enlarged except figure 116, which is less than natural size.)

PLATE XXII.

External Anatomy of Tachytes distinctus.

FIG. 1.—Lateral view of thorax; *1*, prothorax; *2*, mesothorax; *3* metathorax; *4*, propodeum (first abdominal segment—median segment); *Cx*, coxa; *Epm*, epimeron; *Eps*, episternum; *It*, first abdominal segment; *L*, lateral lobe of pronotum; *N*, notum; *pl*, pleuron; *pn*, postnotum; *Scl*, scutellum; *Sct*, scutum; *Sp*, spiracle of first abdominal segment; *tg*, tegula; *2t*, basal portion of second abdominal segment.

FIG. 2.—Lateral view of abdomen; *2*, second abdominal segment; *7*, seventh abdominal segment; *pg*, pygidial area; *s*, sternum; *t*, tergum.

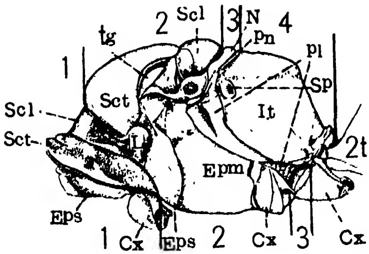
FIG. 3.—Dorsal view of thorax; symbols as in fig. 1; *AF*, apical fovea of propodeum; *F*, parapsidal furrow; *FW*, base of fore wing; *PF*, posterior sulcus of propodeum; *S*, socket of fore wing (the tegula being removed).

FIG. 4.—Ventral view of thorax; symbols as in fig. 1; *S*, sternum.

FIG. 5.—Hind leg, anterior lateral view; *Cx*, coxa; *f*, femur; *Tar*, tarsus; *tb*, tibia; *tr*, trochanter.

FIG. 6.—Anterior (front) view of head; *C*, clypeus; *f*, frons; *g*, glossa; *ia*, ocellar area; *l*, labrum; *m*, mandible; *mx*, maxilla; *p*, labial palpus; *Vx*, vertex.

PLATE XXII.



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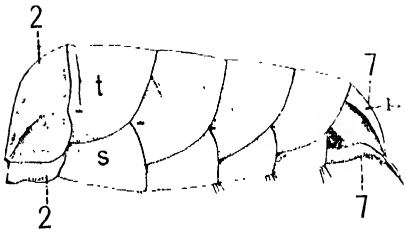

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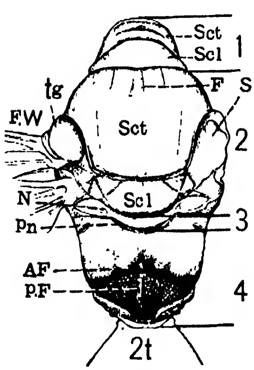

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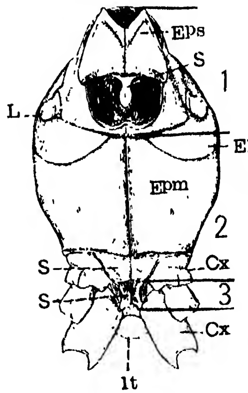

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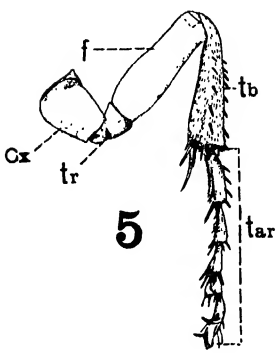

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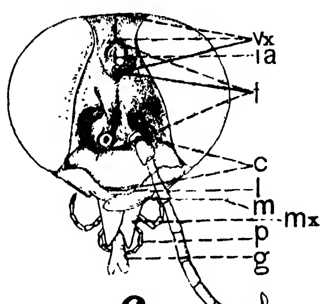


6

PLATE XXIII.

Tachytes distinctus.

FIG. 7.—Ventral view of mouth parts; *C*, cardo (the paler inner half may represent the lorum); *d*, sclerite before labial palpus; *e*, sclerite before tip of mentum, connected with *d*; *f*, prong ("basal hooks of the glossa") of the ventral plate of the glossa; *GL*, glossa; *gr*, ventral apical furrow of ligula; *LP*, labial palpus; *M*, mentum; *MD*, base of mandible; *MP*, maxillary palpus; *MX* galea of maxilla; *O*, ventral portion of occiput; *PGL*, paraglossa; *SMT*, submentum; *ST*, stipe; *x*, ventral supporting plate of ligula.

FIG. 8.—Lateral view of mouth parts exclusive of maxillæ and mandibles; symbols as in fig. 7; *b*, passage to the blind sac *t*; *C*, clypeus; *D*, salivary duct; *EPH*, epipharynx; *g*, ventral plate of glossa; *h*, sclerite on under side of the plate or scale, *i*, of paraglossa; *k*, basal scale of ligula; *L*, labrum; *o*, passage to pharynx; *p*, anterior end or lobe of pharynx; *s*, "hypopharyngeal sclerite" (Sharp); *t*, pouch or blind sac.

FIG. 9.—Interior lateral view of maxilla; *C*, cardo; *L*, lacinia; *SMT*, submentum; *MX*, galea; *N*, less heavily chitinized inner portion of cardo, may be the lorum; *p*, base of palpus; *St*, stipe.

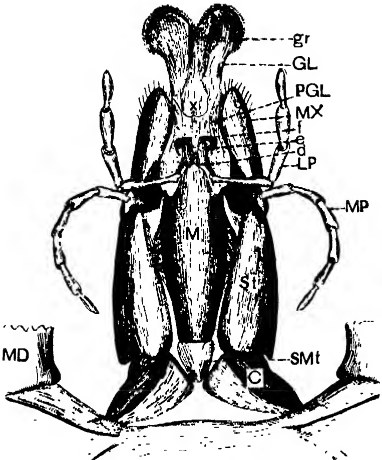
FIG. 10.—A nearly lateral view (ventral portion slightly inclined toward observer) of the mouth parts exclusive of the mandibles; symbols as in figs. 7 and 8; *n*, small sclerite under clypeus; *r*, "epipharyngeal sclerites" (Sharp) = pharyngeal rods.

FIG. 11.—Dorsal view of labium (slightly diagrammatic), to show the path followed by food as indicated by the arrows, lettering as in fig. 8; *A*, apical arrow, the beginning course for liquid food; *b*, second slope of ligula and passage to blind sac; *c*, lower edge of first slope to ligula; *so*, opening of salivary duct; *x*, first slope of ligula.

FIG. 12.—One of the hooks in the middle field of a series along the costal vein, *A*, of the second pair of wings.

FIG. 13.—Anterior view of fore coxæ of male, showing the coxal process, *H*; *tr*, trochanter.

PLATE XXIII.



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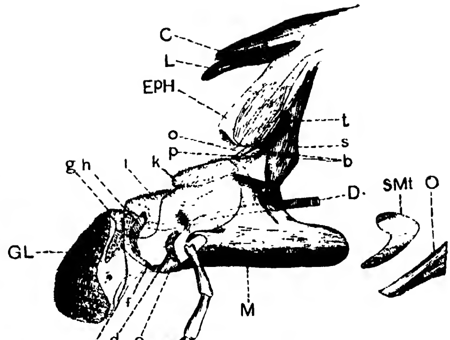

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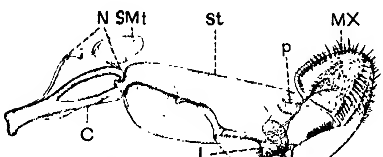

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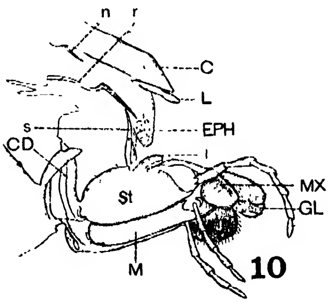

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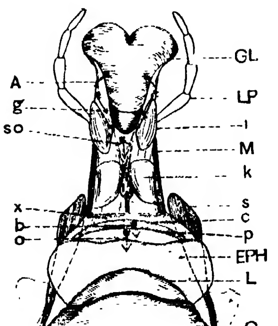

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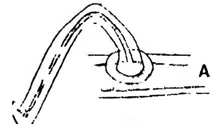

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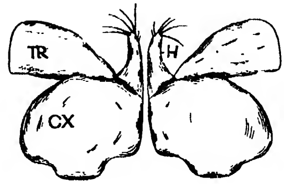

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PLATE XXIV.

FIG. 14.—Fore and hind wing of *Tachytes distinctus* ♀; the *veins* are named according to the system used by Cresson; lettering largely after Fernald (Chlorioninæ of N. A.); *a*, anal; *am*, apical margin; *ap*, appendiculate vein; *ax*, axillary; *b*, basal; *c*, costal; *cu*, cubital; *d*, discoidal; *ff*, frenal fold; *fh*, frenal hooks; *m*, median; *pm*, posterior margin; *r*, marginal or radial; re_1, first recurrent; re_2, second recurrent; *s*, stigma; *sc*, subcostal; *sd*, subdiscoidal; *si*, sinus; tc_1, first transverso-cubital; tc_2, second transverso-cubital; tc_3, third transverso-cubital; *tm*, transverse-median.

FIG. 15.—Fore and hind wing of *Tachysphex propinquus* ♀; the *cells* named according to the Cressonion nomenclature; lettering after Fernald; *a*, anal; ap_1, first apical; ap_2, second apical; *apd*, appendiculate cell; *c*, costal; cu_1, first cubital or submarginal; cu_2, second cubital or submarginal; cu_3, third cubital or submarginal; d_1, first discoidal; d_2, second discoidal; d_3, discoidal; *m*, median; *r*, radial or marginal; *sm*, submedian.

FIG. 16.—Wings of *Larra analis* ♀.

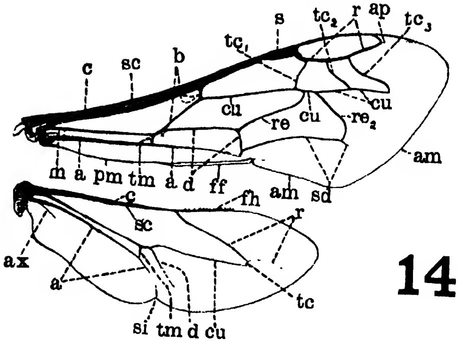
FIG. 17.—Wings of *Bothynostethus distinctus* ♂.

FIG. 18.—Wings of *Niteliopsis foxii* ♀ (type).

FIG. 19.—Wings of *Miscophus americanus* ♀.

FIG. 20.—Wings of *Plenoculus apicalis*.

PLATE XXIV.



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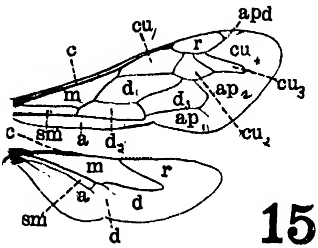

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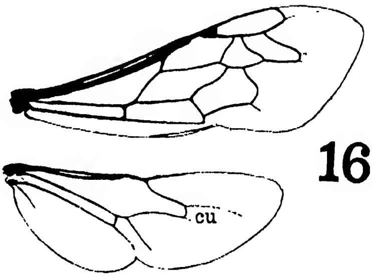

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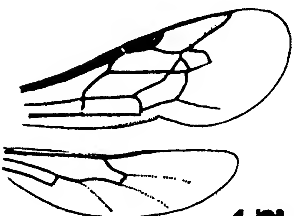

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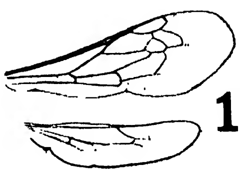

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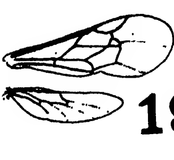

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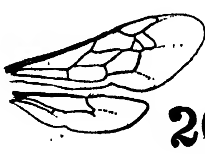

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PLATE XXV.

FIG. 21.—Mandible of *Tachytes distinctus*, showing the emargination.

FIG. 22.—Mandible of *Tachytes distinctus*, showing the two teeth within.

FIG. 23. Mandible of *Larropsis aurantia.*

FIG. 24.—Mandible of *Larra analis*, showing two indistinct teeth within.

FIG. 25.—Mandible of *Tachytes obscurus* ♀. Note that the stout mandible is quite narrowly emarginate.

FIG. 26.—Mandible of *Tachytes mergus.* Note its slenderness.

FIG. 27.—Mandible of *Tachysphex*, showing the deep and rather broad emargination.

FIG. 28.—Mandible of *Niteliopsis foxii* ♀ (type); *A*, lower margin.

FIG. 29.—Joints 2 to 4 of antenna of *Niteliopsis foxii* ♀ (type).

FIG. 30.—Antenna of *Niteliopsis inerme* ♂ ♀.

FIG. 31.—Joints 8 and 9 of antenna of *Tachysphex propinquus* ♂.

FIG. 32A.—Joints 2 to 4 of antenna of *Tachysphex terminatus* ♀.

FIG. 32B.—Joints 2 to 4 of antenna of *Tachysphex fusus* ♀.

FIG. 33.—Portion of the inner (posterior) margin of the fore wing of *Tachytes distinctus*, showing the fold or upturned edge, *F*, of the wing; *AN*, anal vein; *DN*, discoidal vein; *SDN*, subdiscoidal vein.

PLATE XXV.

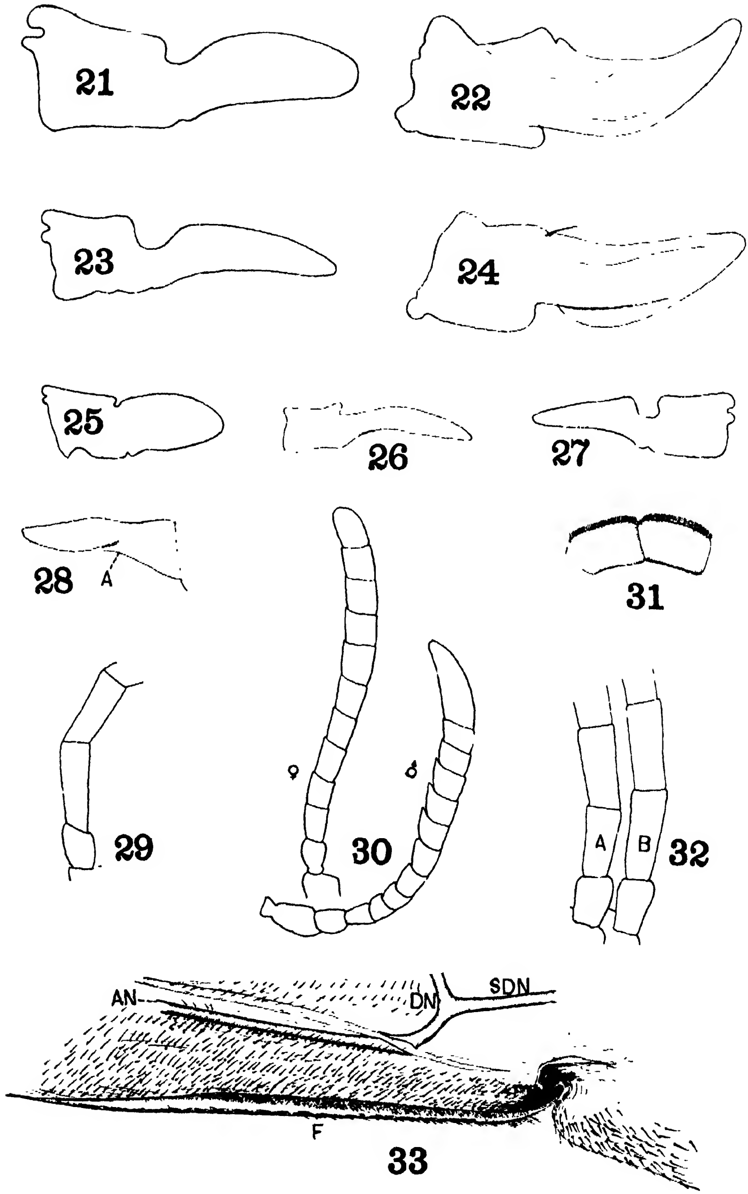

PLATE XXVI.

FIG. 34.—Ocellar area of *Notogonia argentata.* Note the small, nearly transverse posterior ocelli.

FIG. 35.—Ocellar area of *Tachysphex tarsatus.* The posterior ocelli are in a reniform or oblong area.

FIG. 36.—Ocellar area of *Larropsis aurantia.* Note the broad ocellar area.

FIG. 37.—Ocellar area of *Lyroda triloba.*

FIG. 38.—Ocellar area of *Plenoculus apicalis.*

FIG. 39.—Ocellar area of *Tachytes distinctus.* Note the long subparallel posterior ocelli and the rather narrow ocellar area.

FIG. 40.—Antenna of *Tachytes mandibularis* ♂, to show the convexity of the lower surface of joints 3 to 7.

FIG. 41.—Antenna of *Tachytes distinctus; b,* bulb of scape; *f,* flagellum; *p,* pedicel; *s,* scape.

FIG. 42.—Antenna of *Tachytes fulviventris* ♂, to show the broadened joints 9-11.

FIG. 43.—Antenna of *Plenoculus apicalis* ♂.

FIG. 44.—Basal portion of antenna of *Plenoculus apicalis* ♀.

FIG. 45.—Basal portion of antenna of *Plenoculus apicalis* ♂.

FIG. 46.—Tip of fore wing of *Larropsis pænerugosa* ♂ (type).

FIG. 47.—Tip of fore wing of *Tachysphex texanus* ♀.

FIG. 48.—Tip of fore wing of *Tachysphex acuta* ♀.

FIG. 49.—Lateral view of thorax of *Notogonia argentata,* showing the comparatively long propodeum.

FIG. 50.—Semidiagrammatic dorsal view of disc of propodeum of *Bothynostethus distinctus,* showing the character of sculpture.

FIG. 51.—Lateral view of thorax of *Larropsis,* showing the comparatively short propodeum.

PLATE XXVI.

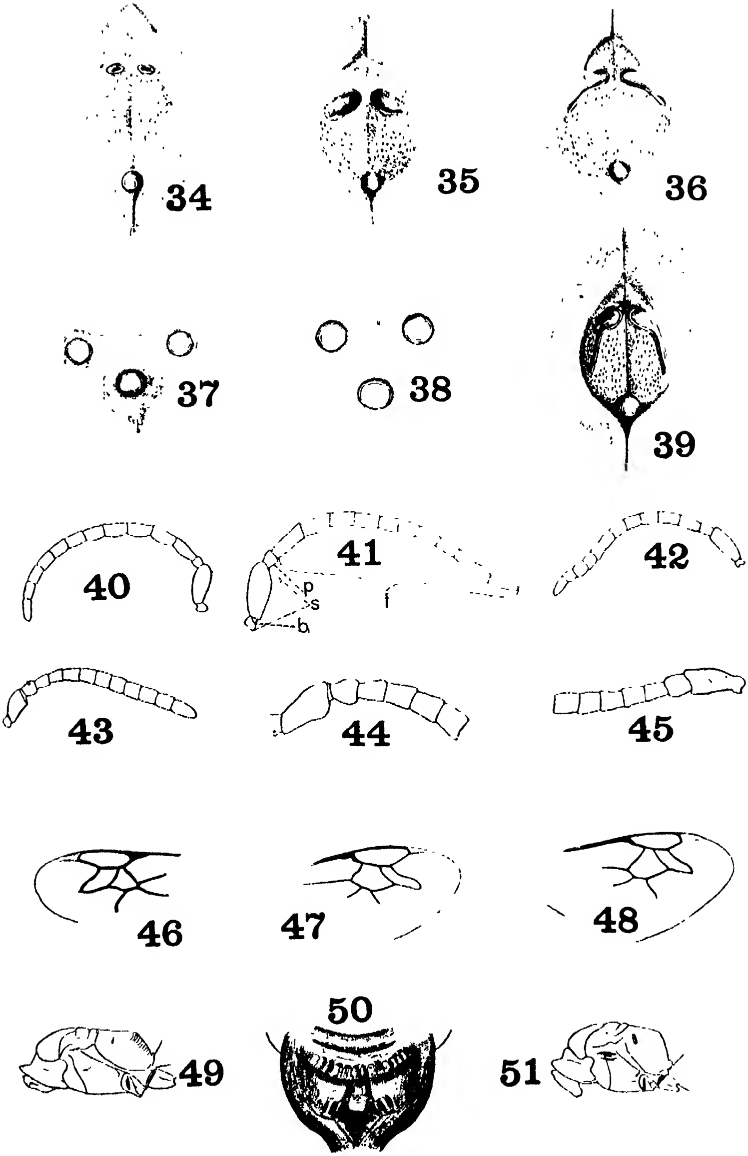

PLATE XXVII.

FIG. 52.—Anterior margin of clypeus of *Tachytes mandibularis* ♂ ♀.
FIG. 53.—Anterior margin of clypeus of *Tachytes rufofasciatus* ♀.
FIG. 53A.—Anterior margin of clypeus of *Tachytes fulviventris* ♂.
FIG. 54.—Anterior margin of clypeus of *Tachytes obductus* ♀.
FIG. 55.—Anterior margin of clypeus of *Tachytes abdominalis* ♀.
FIG. 56.—Anterior margin of clypeus of *Tachytes validus* ♀.
FIG. 57.—Anterior margin of clypeus of *Tachytes distinctus* ♂ ♀.
FIG. 58.—Anterior margin of clypeus of *Tachytes obscurus* ♂.
FIG. 59.—Anterior margin of clypeus of *Tachytes pepticus* ♂ ♀.
FIG. 60.—Anterior margin of clypeus of *Tachytes sericatus* ♀.
FIG. 61.—Anterior margin of clypeus of *Tachytes mergus* ♀.
FIG. 62.—Anterior margin of clypeus of *Tachysphex tarsatus* ♂ ♀.
FIG. 63.—Anterior margin of clypeus of *Tachysphex terminatus* ♀.
FIG. 64.—Anterior margin of clypeus of *Tachysphex fusus* ♀.
FIG. 65.—Anterior margin of clypeus of *Tachysphex glabrior* ♂.
FIG. 66.—Anterior margin of clypeus of *Tachysphex belfragei* ♀.
FIG. 67.—Anterior margin of clypeus of *Tachysphex dentatus* (type) ♀.
FIG. 68.—Anterior margin of clypeus of *Tachysphex crenuloides* (type) ♀.
FIG. 69.—Anterior margin of clypeus of *Tachysphex clarconis* (type) ♀.
FIG. 70.—Anterior margin of clypeus of *Tachysphex propinquus* ♂.
FIG. 71.—Anterior margin of clypeus of *Tachysphex dubius* ♂.
FIG. 72.—Anterior margin of clypeus of *Tachysphex crassiformis* (type) ♀.
FIG. 73.—Anterior margin of clypeus of *Tachysphex propinquus* ♀.
FIG. 74.—Anterior margin of clypeus of *Bothynostethus distinctus* ♂.
FIG. 75.—Anterior margin of clypeus of *Miscophus americanus* ♀.
FIG. 76.—Anterior margin of clypeus of *Plenoculus apicalis* ♀.
FIG. 77.—Anterior margin of clypeus of *Plenoculus apicalis* ♂. Note the tuft of hair on either side.

PLATE XXVII.

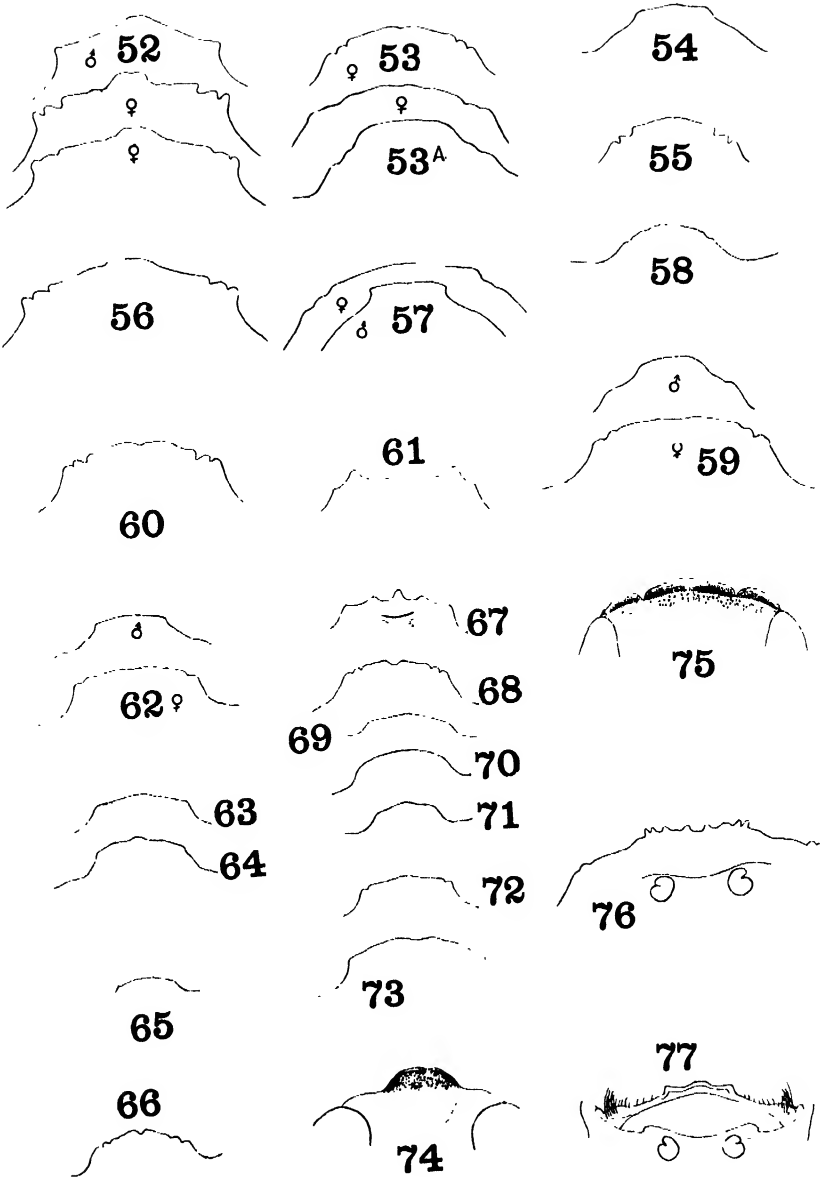
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PLATE XXVIII.

(Figs. 78-81 with the finer hairs omitted.)

FIG. 78.—Fore tarsus of *Larropsis* ♀, showing the fossorial comb of moderate bristles.

FIG. 79.—Fore tarsus of *Tachytes distinctus* ♂ ♀. The ♀ has the fossorial comb much better developed.

FIG. 80.—Fore tarsus of *Notogonia argentata* ♀. Note the weak comb; the insect works more often in heavy soil.

FIG. 81.—Fore tarsus of *Tachysphex propinquus* ♀. The long, flexible spines work to advantage in a sandy country.

FIG. 82.—Hind tibia of *Tachytes abdominalis* ♀, showing a row of stout, blunt thorns on outer side.

FIG. 83.—Ventral view of femur of *Tachytes distinctus* ♂, showing emargination.

FIG. 84.—Lateral view of fore femur of *Larropsis ater* ♂, showing emargination near base. Note the inner tooth; *tr*, trochanter.

FIG. 85.—Lateral view of portion of fore femur of *Tachytes distinctus* ♂.

FIG. 86.—Two views of hind femur of *Bothynostethus distinctus*, showing apical thickening.

FIG. 87.—Lateral view of fore femur of *Tachysphex tarsatus* ♂.

FIG. 88.—Antennal cleaner of *Notogonia argentata; tb*, tibia; *s*, modified spur; *tar*, tarsus with fringed emargination.

FIG. 89.—Antennal cleaner of *Astata* sp., one of the Nyssonidæ, showing the furcation of the modified tibial spur, a character not found in the Larridæ.

PLATE XXVIII.

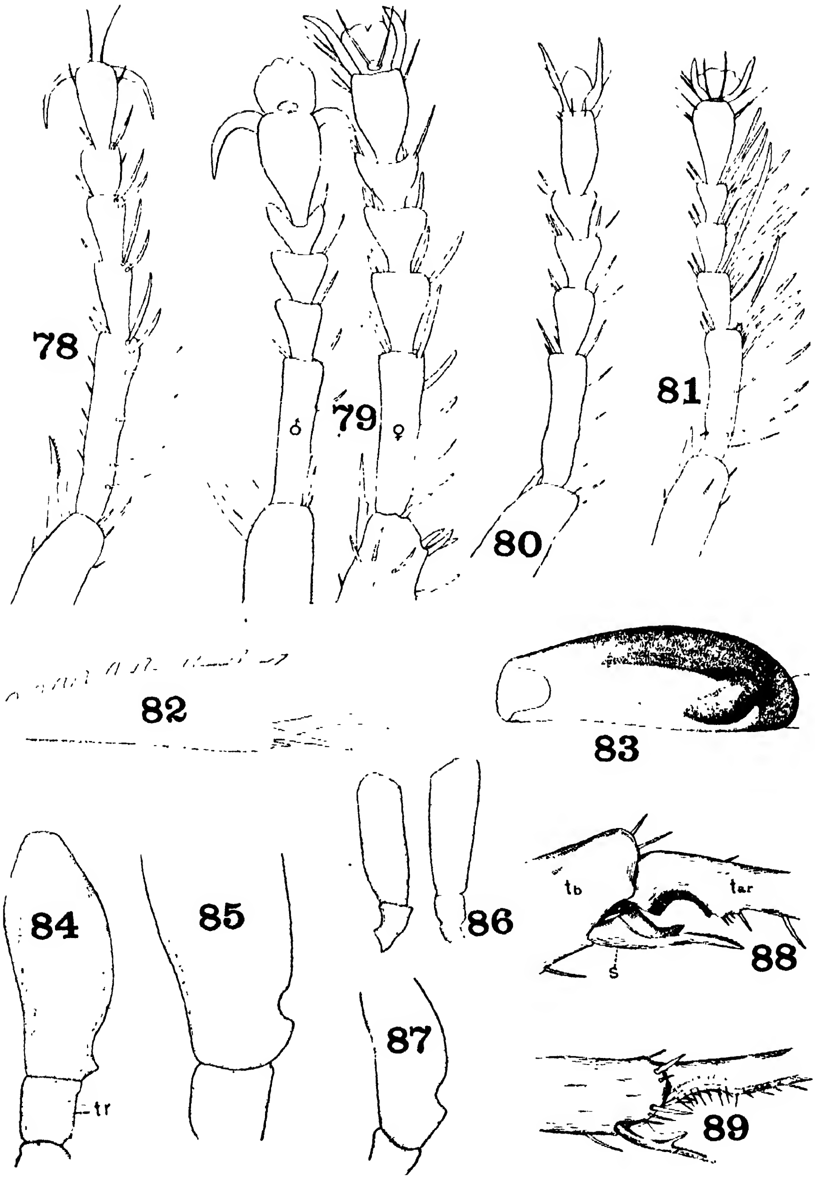

PLATE XXIX.

FIG. 90.—Pygidium of *Tachytes mandibularis* ♀.

FIG. 91.—Pygidium of *Tachytes obductus* ♀.

FIG. 92.—Pygidium of *Tachytes distinctus* ♀.

FIG. 93.—Pyigdium of *Tachytes mergus* ♀.

FIG. 94.—Pygidium of *Tachytes distinctus* ♀.

FIG. 95.—Pygidium of *Bothynostethus distinctus* ♂.

FIG. 96.—Pygidium of *Lyroda subita* ♀.

FIG. 97.—Pygidium of *Notogonia argentata* ♀.

FIG. 98.—Pygidium of *Niteliopsis foxii* ♀ (type). The area has no bounding carinæ.

FIG. 99.—Pygidium of *Larropsis divisa* ♀.

FIG. 100.—Eighth ventral plate of *Larropsis ater* ♂.

FIG. 101.—Eighth ventral plate of *Larropsis bruneri* ♂.

FIG. 102.—Pygidium of *Plenoculus apicalis* ♀.

FIG. 103.—Dorsal view of end of abdomen of *Plenoculus apicalis* ♂, showing eighth ventral segment.

FIG. 104.—Pygidium of *Tachysphex propinquus* ♀.

FIG. 105.—Pygidium of *Tachysphex crenuloides* ♀ (cotype).

FIG. 106.—Pygidium of *Tachysphex dentatus* ♀ (type).

FIG. 107.—Pygidium of *Larra analis* ♀.

FIG. 108.—Apical portion of eighth ventral plate of *Tachytes mandibularis* ♂.

FIG. 109.—Apical portion of eighth ventral plate of *Tachytes pepticus* ♂.

FIG. 110.—Apical portion of eighth ventral plate of *Tachytes fulviventris* ♂.

FIG. 111.—Apical portion of eighth ventral plate of *Tachytes distinctus* ♂.

PLATE XXIX.

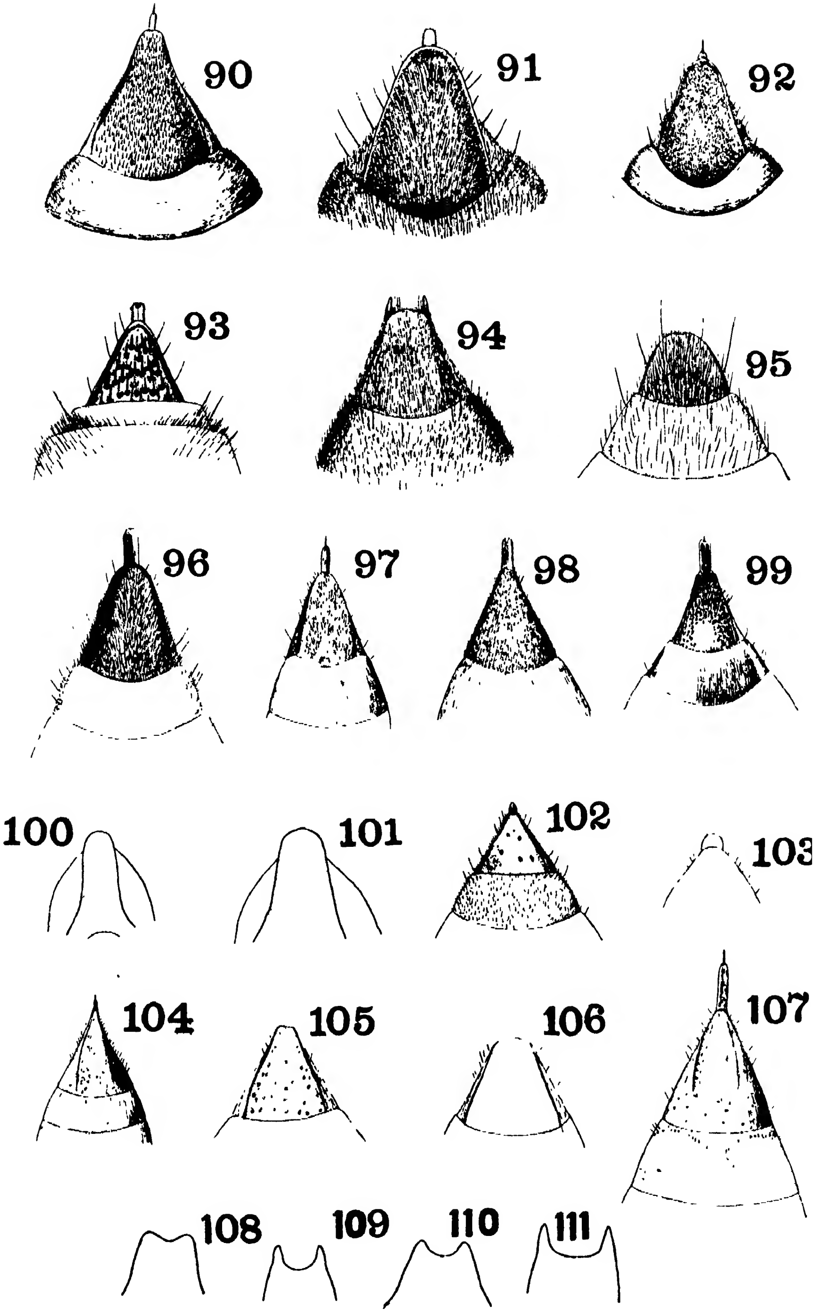
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PLATE XXX.

FIG. 112.—*Tachysphex propinquus* ♀, dragging the locust *Mestobregma kiowa* ♂ to her nest. Grant county, Kansas, August, 1911. The wasp seizes the locust's antennæ with her mandibles and holds the body of her prey with her posterior pair of legs, using the four anterior ones in traveling.

FIG. 113.—Egg of *Tachytes distinctus*. The cephalic end is the more enlarged one, toward the middle of the page.

FIG. 114.—Front and anterior ventral view of a full-grown larva of *Tachytes distinctus*. Rooks county, Kansas, August, 1912.

FIG. 115.—Lateral view of a half-grown larva of *Tachytes distinctus*.

FIG. 116.—Entrance to nest of *Tachytes distinctus*. Rooks county, Kansas, August, 1912.

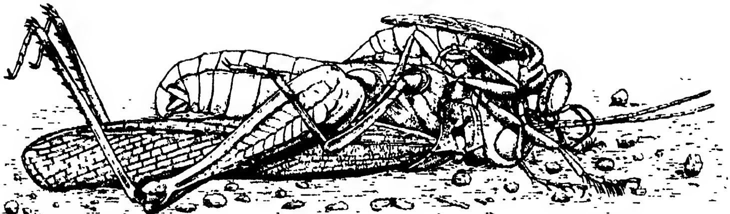
FIG. 117.—Ventral aspect of young Œdipodinæ, showing egg, *E*, of *Tachysphex tarsatus* transversely arranged on prosternum, where it is secured behind the left coxa. Rooks county, Kansas, August, 1912.

FIG. 118.—Ventral aspect of head and thorax of young cricket (*Gryllus*), showing the egg, *E*, of *Notogonia argentata*, secured on inner side and at the base of the left anterior coxa. Lawrence, Kansas, September, 1911.

FIG. 119.—Ventral aspect of young hemipterous insect (Capsidæ), showing the egg, *E*, of *Niteliopsis inerme* transversely arranged behind the fore legs and secured behind the right coxa. Ellis county, Kansas, July, 1912.

FIG. 120.—Ventral aspect of a young hemipterous insect (*Atomoscelis*, fam. Capsidæ) showing a young *Plenoculus apicalis* larva feeding on same.

PLATE XXX.



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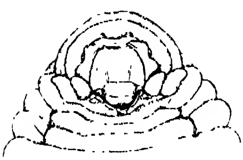

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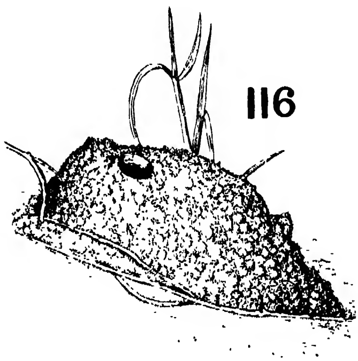

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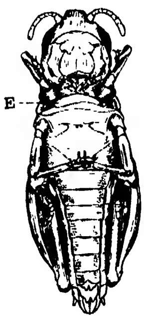

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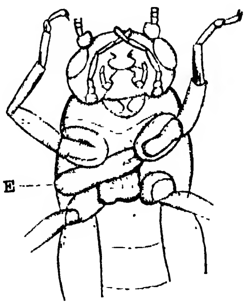

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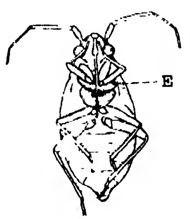

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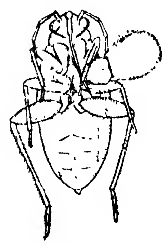

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PLATE XXXI.

Fig. 1.—Adult *Melittia snowi* ♀ (alar expanse, 23 mm.).

FIG. 2.—Mature larva of *Melittia snowi* (length, 26 mm.).

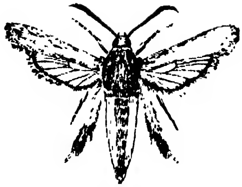
FIG. 3.—Cocoon of *Melittia snowi* (length, 17 mm.).

FIG. 4.—Egg of *Melittia snowi* (length, about .8 mm.).

FIG. 5.—Pupal shell of *Melittia snowi* (length, 18 mm.).

FIG. 6.—Pupal shell of *Melittia gloriosa* ♀ (length, 47 mm.).

PLATE XXXI.



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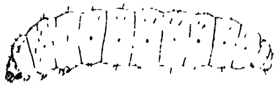

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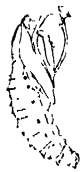

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PLATE XXXII.

Fig. 7.—Galls on *Cucurbita fœtidissima,* made by the larva of *Melittia snowi.*

Fig. 8.—A gall formed from a tendril stem.

Length of shoot (fig. 7), 240 mm.

PLATE XXXII.

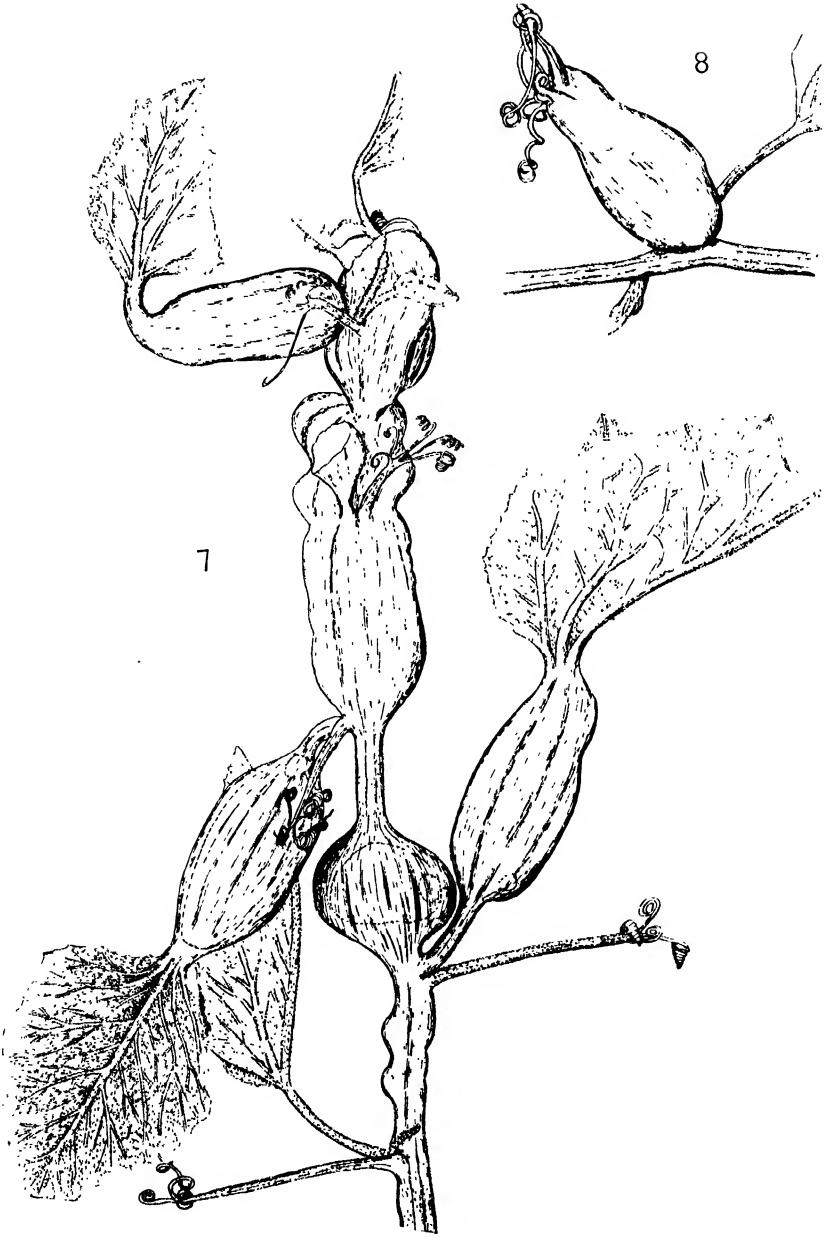

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PLATE XXXIII.

FIG. 1.—*Mimesa argentifrons* ♀ (× 3.8).

FIG. 2.—Burrow of *Priononyx atrata* ♀. Cell contains the locust, *Aulocara elliotti*. About natural size.

FIG. 3.—*Athysanus exitiosa*, the prey of *Mimesa argentifrons* (× 3.8).

FIG. 4.—*Harpactus gyponæ* ♀ (× 3.8).

FIG. 5.—*Gypona cinerea*, the prey of *Harpactus gyponæ* (× 3.8).

FIG. 6.—Dorsal view of *Melanoplus lakinus* ♀, showing egg (*E*) of *Priononyx atrata* (× 1.6).

FIG. 7.—*Priononyx atrata* ♀ (× 1.6).

PLATE XXXIII.

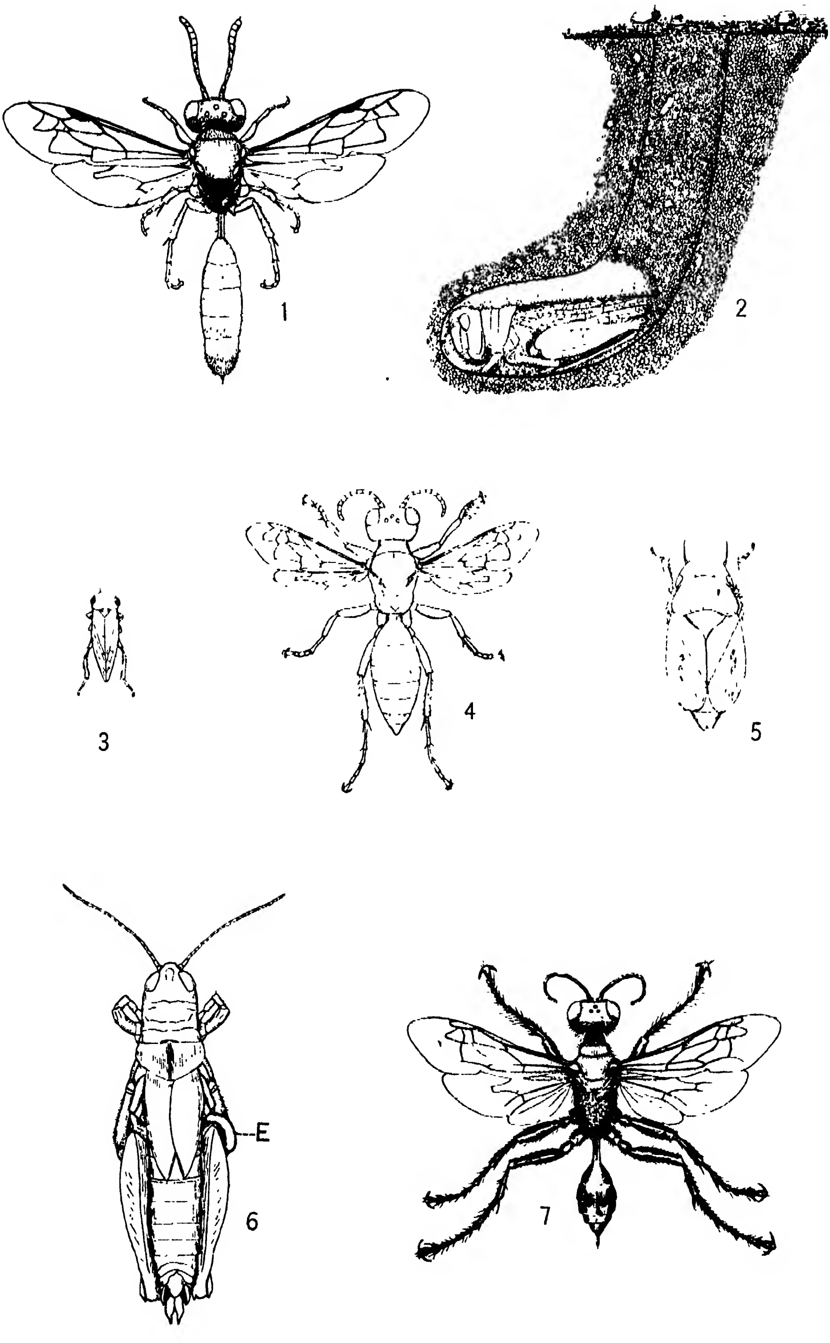

PLATE XXXIV.

FIG. 1.—Vertical section of a nest of *Pt. 5-faciatus;* eggs suspended in cells.

FIGS. 2, 3 AND 4.—Vertical sections of nests of *O. dorsalis,* opening in level ground; eggs suspended in some cells.

FIG. 5.—Vertical section of nest of *O. dorsalis,* opening in face of bank.

FIGS. 6 AND 7.—Vertical sections of nests of *O. arvensis;* tube over entrance.

FIG. 8.—Nest of *Eumenes* on a rock.

FIGS. 9 AND 10.—Nests of *E. bolli.*

FIG. 11.—Earthen bank inhabited by *O. hildagi* and by a colony of *O. papagorum.* Photo by F. X. Williams.

PLATE XXXIV.

FIG. 1.—Vertical section of a nest of *Pt. 5-faciatus;* eggs suspended in cells.

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FIGS. 9 AND 10.—Nests of *E. bolli.*

FIG. 11.—Earthen bank inhabited by *O. hildagi* and by a colony of *O. papagorum.* Photo by F. X. Williams.

PLATE XXXIV.

Fig. 11.

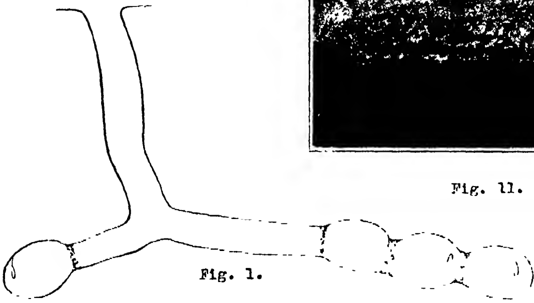


Fig. 1.

Fig. 2.

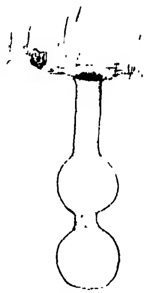


Fig. 3.

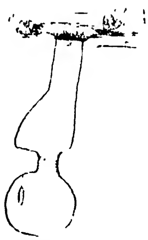


Fig. 4.

Fig. 7.

Fig. 8.

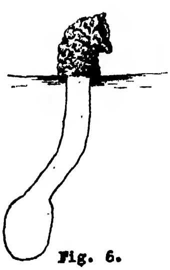


Fig. 6.

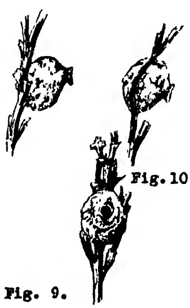
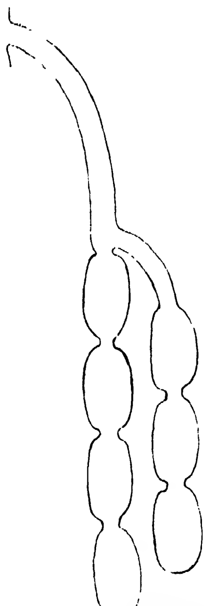


Fig. 10.

Fig. 9.



D.I.- O.A.

Fig. 5.

PLATE XXXV.

FIG. 12.—Vertical section of nest of *O. hildagi.*

FIG. 13.—Cell of nest of *O. hildagi.*

FIG. 14.—Vertical section of nest of *O. annulatus*; tube over entrance.

FIG. 15.—Vertical section of nest of *O. annulatus*; all parts brought into one plane; tube removed.

FIG. 16.—Tube over entrance to nest shown in figure 15.

FIG. 17.—Tube extending from bank over entrance of nest of *O. papagorum.*

FIGS. 18 AND 19.—Horizontal sections of burrows of *O. papagorum*, showing arrangement of entrances of cells and galeries into main burrow.

FIGS. 20 AND 22.—Vertical sections of nests of *O. papagorum*, with tubes over entrance.

FIG. 21.—Vertical section of lower part of a nest of *O. papagorum;* eggs in cells.

FIG. 23.—Nest of *E. fraternus.*

PLATE XXXV.

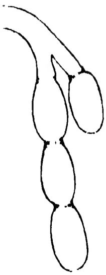


Fig. 12.

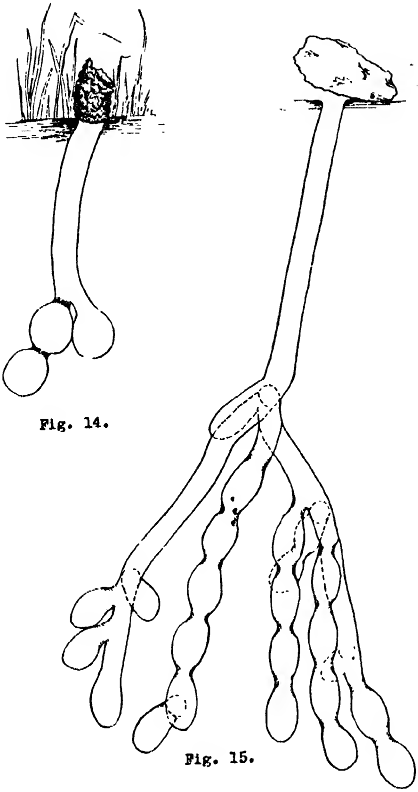


Fig. 14.

Fig. 15.

Fig. 16.

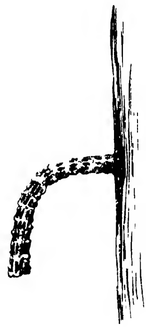


Fig. 17.

Fig. 13.

Fig. 23.

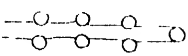


Fig. 18.

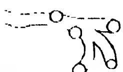
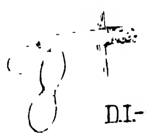


Fig. 19.

Fig. 20.

Fig. 21.



D.I.-O.A.

Fig. 22.

PLATE XXXVI.

FIG. 24.—*O. papagorum.*

FIG. 25.—*O. arvensis.*

PLATE XXXVI.

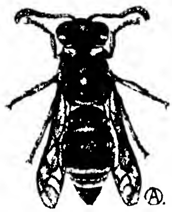


Fig. 24.

Fig. 25.

PLATE XXXVII.

FIG. 26.—*E. bolli.*

FIG. 27.—*Pt. 5-faciatus.*

PLATE XXXVII.

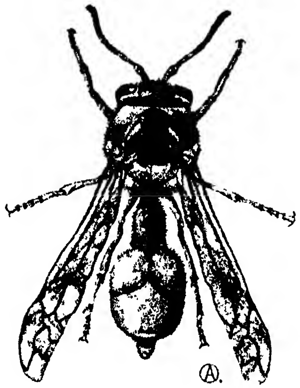


Fig. 26.

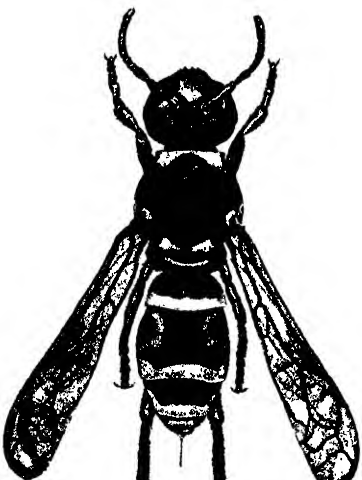


Fig. 27.

PLATE XXXVIII.

FIG. 1. Typical breeding place of *Simulium vittatum*, Turkey creek, Oswego, Kan.

FIG. 2. Pupæ on the under side of a stone, from ripples in the stream shown in figure 1. (Slightly reduced.)

FIG. 3. A *Simulium* fly trap in a ripple, showing the method of catching the flies as they emerge. When removing the flies from the trap a black cloth is put around the white cone over which Prof. S. J. Hunter is holding a glass bottle for the flies to emerge into.

PLATE XXXVIII.

Fig. 1

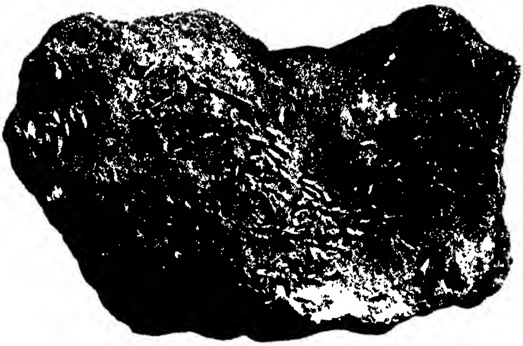


Fig. 2

Fig. 3

PLATE XXXIX.

FIG. 5. Female *S. vittatum.* (Greatly enlarged).

FIG. 6. Male *S. vittatum.* (Greatly enlarged).

FIG. 7. Dorsal view of Simulium pupa removed from pupa case, showing pupal breathing gills and development of wing pads.

FIG. 8. *Simulium* pupa immediately after transforming from the larval state, showing the immature development of wing pads.

FIG. 9. Lateral view of pupa, showing the membrane which holds it in the pupa case.

FIG. 10. Adult *Simulium* larva.

FIG. 11. Adult *Simulium* larvæ, showing the proleg at *P* and the caudal aperture at *A*. (See plate XVI, figure 34, *A*.)

FIG. 12. *Similium* egg highly magnified.

FIG. 13. Mass of *Similium* eggs magnified.

FIG. 21. Mandibles and part of clypeus.

FIG. 23. Labrum and hypopharynx united. *A* and *B*, points of attachment; *H*, hypopharynx; *L*, labrum.

FIG. 25. Wing of *S. vattatum.*

PLATE XXXIX.

Fig. 5

Fig. 7

Fig. 6

Fig. 8

Fig. 9

Fig. 12

Fig. 10

Fig. 13

Fig. 21

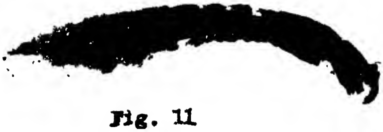


Fig. 11

Fig. 23

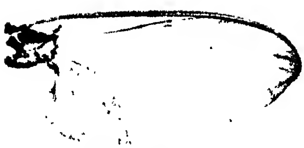


Fig. 25

PLATE XL.

FIG. 14. Composite view of head and mouth parts of *Simulium vittatum*. *E*, eyes; *C*, clypeus; *MD*, mandible; *MX*, maxilla; *LA*, labrum; *ooo*, muscular attachments of labrum and clypeus; *LM*, labium; *HPY*, hypopharynx; *oo*, attachments of hypopharynx and labrum.

FIG. 15. Lacina of maxilla, greatly enlarged, showing the barb-like teeth turned backward on it.

FIG. 16. End of labrum, showing the chitinized parts and the two teeth.

FIG. 17. Maxilla of *S. vittatum*. *C*, cardo; *S*, stipes; *PF*, palpifer; *L*, lacina; *PA*, palpus.

FIG. 18. End of mandible, greatly enlarged to show the saw-like teeth on its end.

FIG. 19. Antennæ of *S. vittatum*.

FIG. 20. *C*, clypeus; *M*, mandibles.

FIG. 22. Mandible. *C*, condyle (?) of mandible.

FIG. 24. *A' B'*, points of hypopharynx where *A* and *B* of the labrum attach.

PLATE XL.

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PLATE XL.

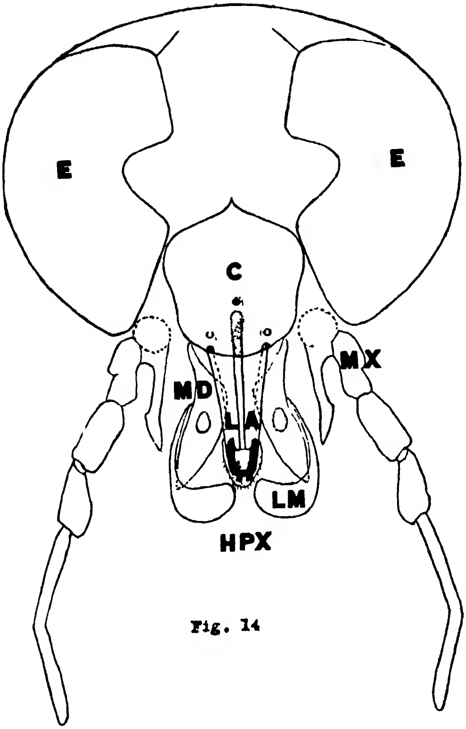

Fig. 14

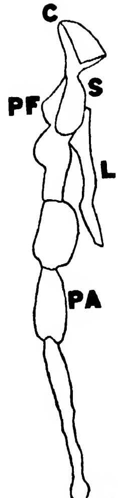

Fig. 17

Fig. 15

Fig. 22

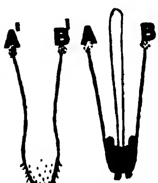

Fig. 24

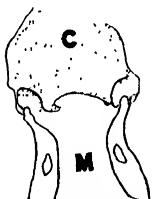

Fig. 20

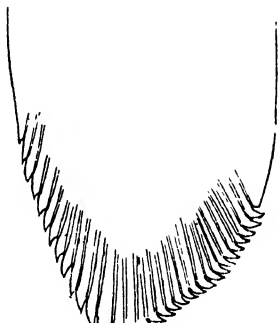

Fig. 18

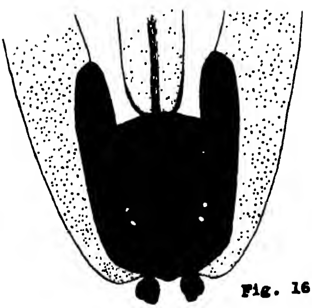

Fig. 16

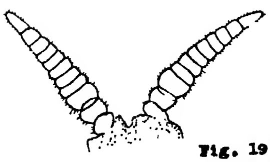

Fig. 19

PLATE XLI.

FIG. 26. Composite view of head of a female *S. vittatum*. (All photographs of the fly except the one of the pupæ on the stone are greatly enlarged views of the specimens.

FIG. 27. Hypopharynx and maxilla of *S. vittatum*.

FIG. 28. Composite view of mouth parts, showing all the parts intact except the labium, which is entirely removed. The hypopharynx is turned under and upward in the photograph.

FIG. 29. Male *S. vittatum* mouth parts. Note the tip of the labrum has the two teeth coalesced. Note the difference in the size of the facets of the eye.

FIG. 30. Labium of female. All mouth parts figured are of the female except figure 28. *G*, glossa; *PG*, paraglossa; *M*, mentum.

FIG. 31. Ventral view of head of *Simulium* larva, showing the fan-like organs spread out.

FIG. 32. *MD*, mandible of *Simulium* larva; *AT*, antennæ of *Simulium* larva. (According to Johannsen.)

FIG. 33. Maxilla of *Simulium* larva, showing the palpus at *P*.

FIG. 34. Labium of *Simulium* larva.

FIG. 35. *LA*, labrum of *Simulium* larva; *HY*, hypopharynx of *Simulium* larva; *A*, anal aperture of *Simulium* larva. The U-shaped part lies dorso-cephalad to the rest of it in the larva. Note the rasp-like formation of this organ. The larva uses it to hold onto the stones in the ripples.

PLATE XLI.

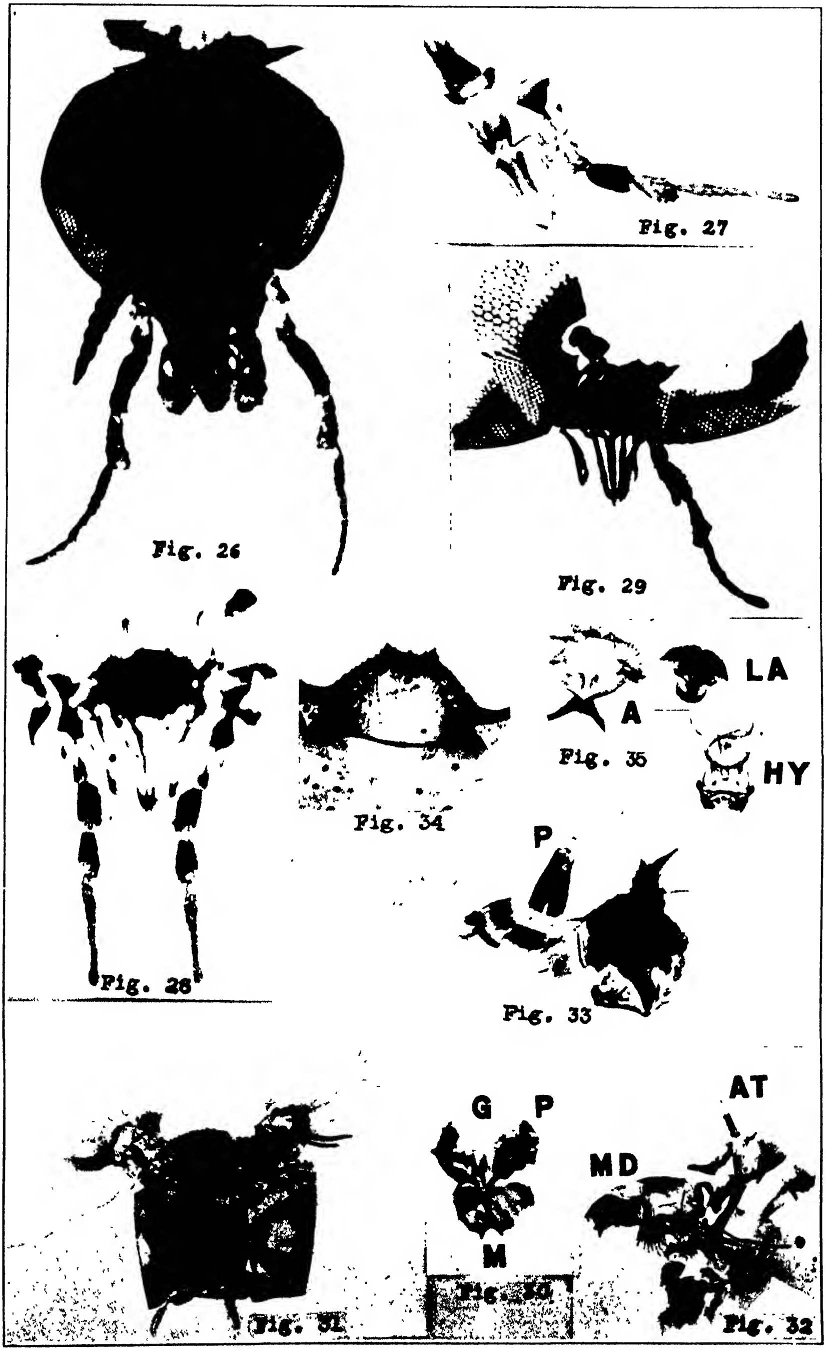

Fig. 26
Fig. 27
Fig. 29
LA
A
Fig. 35
HY
Fig. 28
Fig. 34
P
Fig. 33
G
P
M
AT
MD
Fig. 32

PLATE XLII.

Map of Kansas, showing the location and distribution of *Simulium* flies. A complete survey of Kansas for *Simulium* has not been made, but the survey that has been made to date as shown by the map would indicate that *Simulium* flies are generally distributed over the state where there are year-round flowing streams of water. *S*, location of *Simulium*.

PLATE XLII.

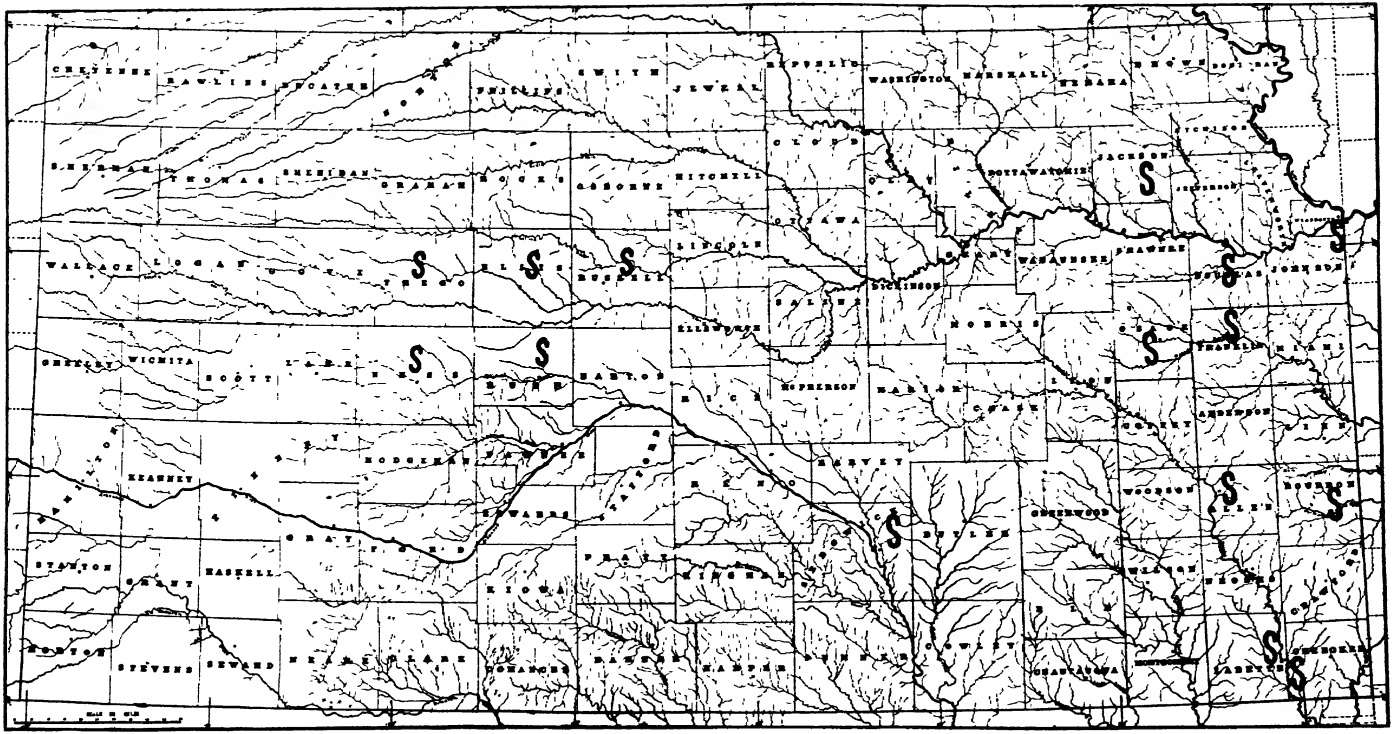
CHEYENNE
RAWLINS
DECATUR
PHILLIPS
SMITH
JEWELL
WASHINGTON
MARSHALL
NEMAHA
BROWN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
JACKSON
POTTAWATOMIE
OTTAWA
LINCOLN
WALLACE
TREGO
SHAWNEE
JOHNSON
DICKINSON
ELLSWORTH
MORRIS
FRANKLIN
MIAMI
WICHITA
SCOTT
McPHERSON
CHASE
KEARNEY
HARVEY
BUTLER
GREENWOOD
WOODSON
EDWARDS
STANTON
HASKELL
GRANT
KIOWA
WILSON
STEVENS
SEWARD
CLARK
COMANCHE
HARPER
CHAUTAUQUA
MONTGOMERY

PLATE XLIII.

Fig. 1.

Lateral view of female fly.

Pn—Pronotum.
n—Notum of mesothorax.
ms—mesothoracic spiracle.
m's—metathoracic spiracle.
m"s—mesosternum.
as—abdominal spiracles.
tr—tarsi.
c—costa.
sc—subcosta.
e—emargination marking junction of r with costa.
r—radius.
r+—radius 2+3+4+5.
m+m'—media 1 and 2.
cn—cupitus.
a—anal veins.

Fig. 2.

Dissection study of fly from left side.

In the thorax the oblique muscles have been removed to show the left longitudinal thoracic muscle in place but shrunken—the trachea, t, is shown also in figure 5 as dotted. A portion of the metathoracic integument (in) is left intact to show metathoracic spiracle.

s—stomach.
mp—Malpighian tubules of left side shown.
h—dorsal vessel.
rp—rectal pouch also shown in fig. 3.
i—chitinized invagination.
th—muscle of thorax.

Fig. 3.

Rectal pouch showing striations and three of the papillæ—rp. These show the nuclei, having been stained with borax carmine.

Fig. 4.

Salivary glands.

d—common duct leading to salivary receptacle.
r—reservoir.
g—gland showing nuclei—from a stained specimen.

PLATE XLIII.

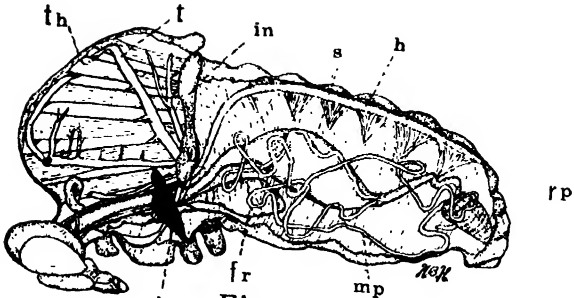

Fig. 2

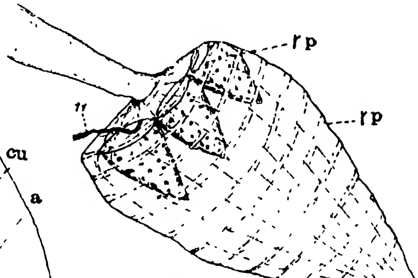

Fig. 3

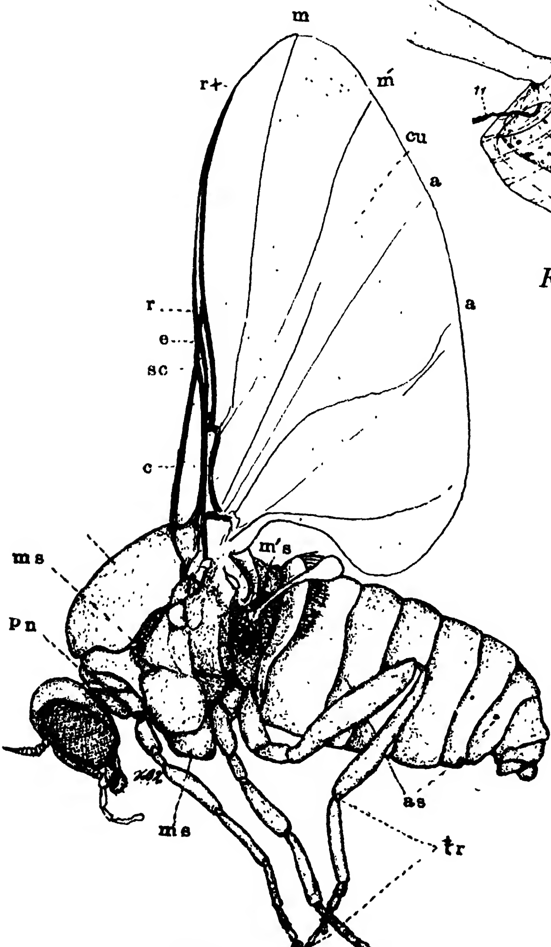

Fig. 1

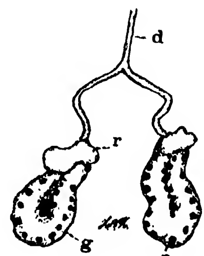

Fig. 4

H.B. Hungerford - - del.

PLATE XLIV.

FIG. 5.

Integument of left side removed to show tracheal system. Trachea dotted in—not visible from surface view. Portions of integument left to support the meso- and meta-thoracic spiracles.

ms—mesothoracic spiracle.
m's—metathoracic spiracle.
in—integument of meta thorax.
tr—trachea.
mt—main trunk of trachea in thorax.

FIG. 6.

Reproductive and nervous systems.

ov—ovary (left).
s—salivary gland (left).
nc—nerve cord.
st—spermatheca.
c—chitinized invagination.

FIG 7.

Female genital apparatus—view from above.

st—spermatheca.
cr—chitinized rod.
ag—accessory glands.
rp—rectal pouch.
n—muscular attachment of chitinized rod.

FIG. 8.

v—terminal valves.
go—genital pore.
r—attachment of cephalic end of the chitinized rod shown in figure 7 The black line shows the arch of the chitinized rod.

FIG. 9.

Ventral view of abdomen of female showing fat body and ovaries in position.

F—fat body.
n—Malpighian tubule.
ov—ovary.
sp—spermatheca.
a—anus.

PLATE XLIV.

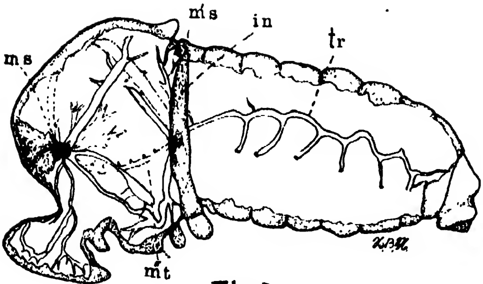

Fig. 5

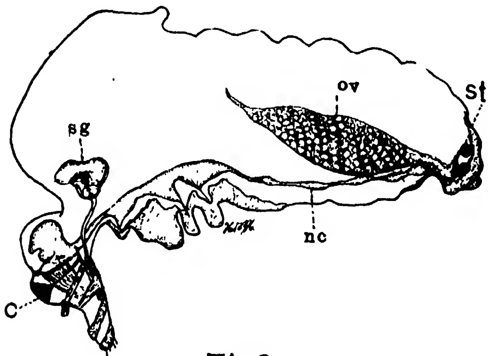

Fig. 6

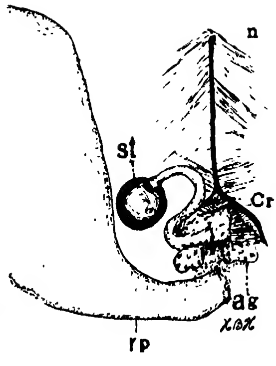

Fig. 7

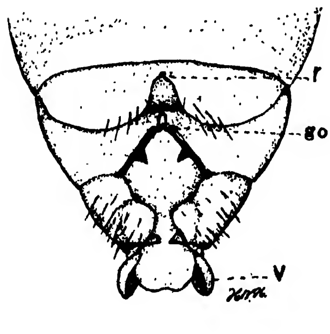

Fig. 8

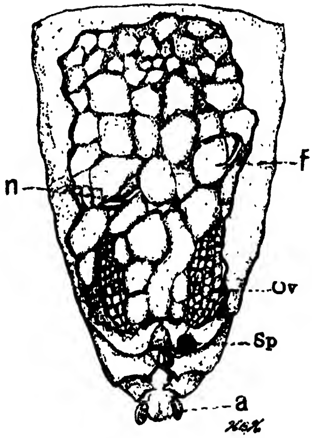

Fig. 9 H.B.Hungerford del

PLATE XLV.

FIG. 10.

Sketch showing attachment of maxilla to chitinized brace of head.

FIG. 11.

Head and food reservoir.

c—chitinized color.
Ph—pharynx.
sy—salivary receptacle.
œ—œsophagus.
Per—proventriculus.
Fr—food reservoir.

FIG. 12.

Projection drawing of a microtome section of head.

tm—thoracic muscle.
br—brain.
roe—œsophageal muscle.
Phy—muscles of pharynx.
lm—muscles of labrum.
sr—salivary reservoir.
Ph—pharynx.
g—œsophageal ganglion.
lr—labrum.

PLATE XLV.

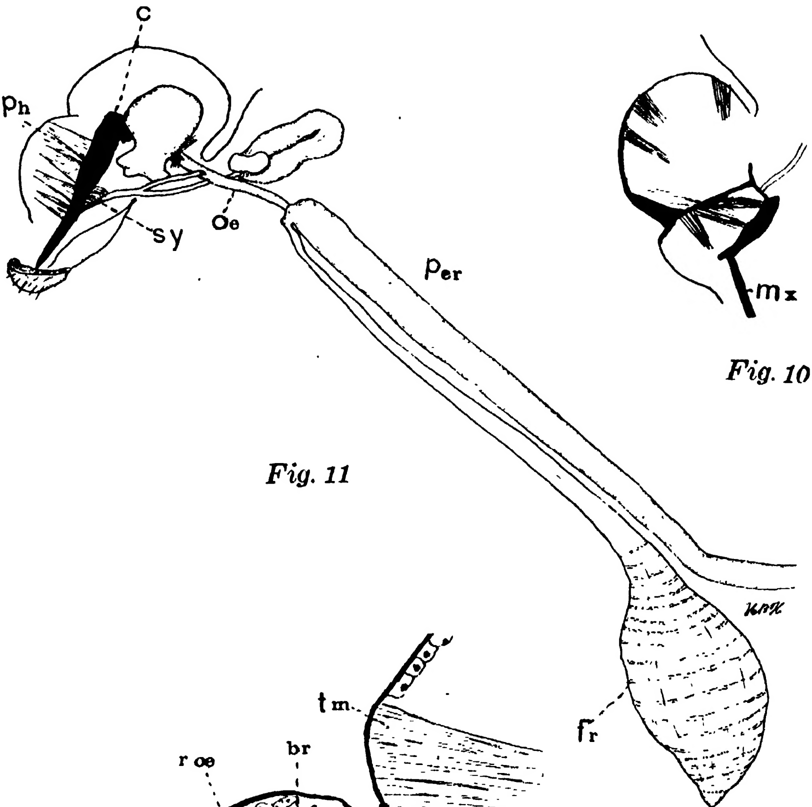

Fig. 11

Fig. 10

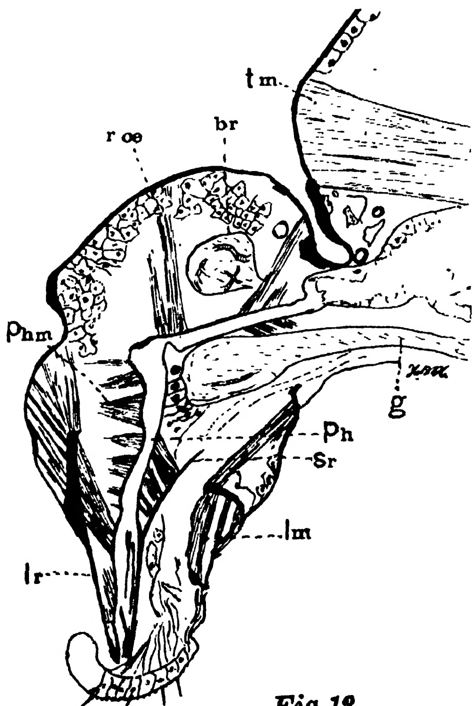

Fig. 12

H.B.Hungerford del.